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The School City.

[*The report of the Franklin Institute, through its Committee on Science and the Arts, on the system of civic education devised by Wilson L. Gill, of New Paltz, N. Y.*

Sub-Committee: Louis E. Levy, chairman; Samuel P. Sadtler, Lewis M. Haupt, Martin I. Wilbert, Harry F. Keller, Raimundo Cabréra.]

[No. 2293.]

The Franklin Institute, acting through its Committee on Science and the Arts, investigating the system of civic education originated by Mr. Wilson L. Gill, of New Paltz, N. Y., and known as the School City, reports as follows:

The essential feature of this invention, for as such, in the strict sense of the term, it is to be regarded, consists of a novel method of school organization devised for the purpose of perfecting the existing general school system by the addition of a method of teaching social science objectively; in other words, of imparting a knowledge of the mechanism of government by means of object lessons, and in such manner as to bring this fundamental but complicated subject-matter within the comprehension of school children.

The correlation of the individual and the community has naturally been a matter of immediate interest from the beginnings of society, and the adjustment of these relations, the function of government, has likewise always been a matter of paramount importance. In the processes of government the individual was long held as the subject rather than the object of its functions, the people being regarded as belonging to the governing power instead of the power belonging to the people. In these cruder stages of social evolution, civic relations have always been viewed in the light of military or religious considerations, and regulated from the standpoint of monarchic or hierarchic interests. Thus the duty of the individual to the community was commonly regarded among the Greeks and Romans from the military point of view, in the mediæval systems from the religious standpoint; and later, in the Renaissance period, from both combined, or rather most frequently from both in opposition. Throughout all these stages the rights of the individual were scarcely considered as existing at all, and at best were but dimly recognized as important, until finally, after centuries of groping, the American Revolution formulated these rights into a modern creed and the French Revolution destroyed the older ones.

From that point to the present the advance in this direction, as in all other avenues of progress, has been very marked. With a growing perception of the true relations of the people and the government, the study of these relations has developed into a science, based, as all true science must be, on natural predicates and proceeding logically in the light of experience and facts. It was yet long, however, before the science of government was disentangled from political history, and longer yet before it was definitely recognized as apart from the science of political economy, with which it had been relegated to the purview of colleges, universities and other seats of higher learning. It is only within the present generation that the distinction has been clearly drawn and only within recent years that the science of Civics, the mechanism of government, has been appreciated as a proper subject of study in our common schools.

The modern scientific theory of civic organization, and that on which our system is based, is that of popular self-government, but this ideal is as yet but imperfectly realized in practice. The theories formulated in our constitutions and our charters are scientifically correct and fully practicable, but the actual results fall far below the theoretical requirement. This is most manifest in the workings of our minor governmental organizations, it being true in this domain, as in that of mechanics, that the theoretical result is most apt to be approximated in the larger units. Thus the theory of government of the people by the people is most nearly realized in the workings of our general system, both as regards its practical efficiency and its ethical qualities as well. It is less so in the case of the component units, particularly the smaller ones, where both the practical and moral aspects of the subject are often equally unfavorable. The low efficiency of our township governments is but too frequently evinced in defective school facilities, still more defective roads and in other manifestations of civic torpor, while our municipal governments, with larger and wealthier constituencies, are proportionately scarcely more efficient than the former and but too often disproportionately corrupt.

It behooves us to study earnestly the cause of these conditions. The soundness of the theory on which our system of government proceeds cannot be logically questioned. Its fundamental principle, once so memorably summarized as "a government of the people, for the people and by the people," is clearly in accordance with the nature of things and with the normal condition of human nature. It works out satisfactorily in many respects and it fails, where it does fail, not through any defect in the principle, but through its defective application. The shortcoming lies not in our civic organization, not in our mechanism of government, but in the manner of its use. Applying here, as especially pertinent, a current figure of speech, it is not in the guns, but in the men behind the guns, that the failure of the combination lies. It is in our educational system that the shortcoming is to be found, and not so much in lack of education as in the lack of such training as will make it practi-

cably effective. The theory of civics is, indeed, taught in our schools, but the art of civics remains unappreciated or at best but vaguely understood. An understanding of any practical science can only be gained experimentally and the science of government is no exception to this rule. It is being taught in formulas, but not in practical application, and the result remains such as is obtained when physics and chemistry are taught in like manner. For these latter our high schools have laboratories for practical demonstration, and even the lower grades utilize physical apparatus for the same purpose. With higher efficiency in all directions constantly demanded by the growing exigencies of our day, and with the requirements of citizenship constantly growing under the increasing complexity of social affairs, there is need that special effort be given to fulfil these requirements. We have established courses of manual training, of industrial art, of technology generally in order to impart to the rising generation a knowledge of the applied sciences; it appears to be time, in view of all the conditions, that the teaching of the theories of civics be supplemented with lessons in the practical art.

It has long been recognized by leaders in educational progress that object lessons are indispensable in the teaching of objective facts. As early as the middle of the seventeenth century the Moravian bishop Comenius, working in various countries of Europe, urged as a basic principle of education that the teaching of words and the things they signify must go hand in hand, and in England Milton took up the same idea and made it a theme of the "Tractate of Education," which he wrote and published. The fundamental idea of the school system organized by Comenius for the kingdom of Sweden, 1642–46, was to take full advantage of the innate tendency of children to exercise their faculties and to utilize this natural desire for activity in the process of their education. He preceded his contemporary, Milton, in pointing out that antagonisms between pupils and their teachers became reflected in a repugnance to learning, and he sought in every way to remove this obstacle. His life-long labors for the improvement of educa-

tional methods might have had other than the sporadic results that were obtained but for the turbulencies of the Thirty Years' War and the religious animosities growing out of it, and it waited another hundred years until Rousseau, in 1762, gave Europe another impulse to educational reform. He, too, like Comenius, looked to the natural processes of life for guidance in the education of the child, and, more fortunate than his predecessor, he found an apt psychological moment for the propagation of his ideas. His doctrines profoundly affected the educational direction of the rising generation of his day, but they had scarcely time enough to do more than help to usher in the French Revolution when in common with many other outgrowths of the times they were suffused in that eruption. But Rousseau's influence had been enough to leave its impress on the neighboring countries of Switzerland and Germany at least, and eventually through these channels on the modern educational system generally. It was his work that influenced Pestalozzi, who took up Rousseau's ideas in Switzerland and there gave them a more practical and realistic turn. His fundamental idea was the combination of training with instruction, and his methods consisted in directing the faculties of observation and perception with the view to developing judgment as well as understanding. Pestalozzi's activity was continued into the early decades of the nineteenth century, and his efforts influenced largely the tendencies to improvement in school methods which have proceeded since his time. It was under his tuition that Froebel crystallized his own original conceptions of the education of young children. He perceived that Pestalozzi's idea that the child belongs to the family and Fichte's idea that it belongs to the community were each but half-truths and that both concepts, like all half-truths, were apt to be mischievous and misleading. The child belongs both to the home and to society; both have an abiding interest in its present and future welfare. Froebel's guiding thought was that the process of education through which the child gradually learns to take its place in the family circle, should be continued in school, so that it may likewise learn to take

its place in the community. His experience as a soldier had impressed him with a realizing sense of the fact that the individual is but a functionating part of the social organism, and that a complete development of both required of the individual the full and proper performance of his functions. Out of these conceptions grew his doctrine of "Selbstthätigkeit," spontaneous activity, from which he deduced the corollary that man learns truly only through voluntary action. He felt the importance of so training the natural impulses of the child that it should spontaneously act in harmony with the general well-being, and to that end he sought to influence the child from its earliest years in such a manner as to imbue it with a sense of its responsibility. He found a way to realize his ideas in the Kindergarten, where the child is trained to pursue its natural home life, play, in common with numerous of its fellows, under the discipline of communal proceeding, and where it is taught the rudiments of manual skill.

As usual with all innovation on accustomed methods, Froebel's system of child culture encountered opposition on every hand, including even the ministry of public education of the kingdom of Prussia, where it was not permitted until long after it had been gladly welcomed and had become deeply rooted in Switzerland, England and the United States. Froebel's system has been greatly developed since his death in 1852, mainly, however, in the direction of manual training. The complex industrial system which has grown up within that time has inevitably caused this trend, but the increasing complexity of modern society which has been incidental to that growth, especially in large centers of population, has come to demand that the sociological feature of the Kindergarten be now developed, as the industrial feature has been already. The new conditions of society impose new duties and larger responsibilities on its individual members, and the demand that has grown with this condition is for such addition to our educational facilities as will afford the means for training the rising generation in the performance of these duties. This demand has been met by the School City System worked out by Mr.

Gill, which manifestly offers practical means to the end in view, and which, in the light of several years' experience and from the concurrent testimony of numerous competent observers, is fully adequate for its purpose.

The School City System consists in organizing each school into a self-governing community, the members of which act as enfranchised citizens and constitute a miniature city government through officials elected from among themselves. The organization is begun by convening the pupils in a general or town meeting, to which the principal and teachers accord a charter, incorporating the school as a municipality and giving each pupil the status of an elector. This, in itself, affords a striking object lesson in this fundamental procedure of city government. Each class in the school is then organized into a city ward, which elects one or more delegates to a nominating convention, through which candidates for the various general offices, such as Mayor, Sheriff, Judges, etc., are proposed for the suffrages of the citizen pupils, who thereupon determine the election by majority vote. Each ward, furthermore, elects two or more members to represent it in the city councils. The Mayor nominates his executive assistants subject to the approval of the councils, including the heads of the Health, Fire and Police departments, and each of these officials in turn selects his assistants, subject to the Mayor's approval, the police force being made up of several pupils from each class.

The disciplinary regulations of the school are formulated by the city councils in due conformity with the requirements of the occasion and subject, of course, to the final revision of the school principal. These regulations are designed to cover all the various phases of school life apart from the courses of study and the school curriculum generally, and include such subjects as cleanliness, sanitation, orderliness and general decorum, all of which usually requires the constant attention of the teachers, sometimes to such an extent as to materially interfere with, if not actually to reduce the efficiency of their tutelage. Under this new system of discipline the work is relieved of much

of its burden, the school regulations being thus in charge of the pupils themselves. It lies in the very nature of things that the children at once realize their individual responsibility, and knowing instinctively, as well as from their experience, the necessity for these regulations, they feel an individual interest in seeing them properly observed. Infractions of the regulations are first called to the attention of delinquents by the police force appointed for the purpose, and if not corrected, the culprits are called before the judges, who try the case, weigh the evidence and fix the penalty, the greatest punishment being deprivation of the rights of citizenship, which relegates the offender to the jurisdiction of the principal and teachers, and bars him from the general organization. The jury system can be added as occasion requires, and is practicably applicable in the more advanced classes of older children. The term of the various offices is made short, especially those of the police department, so as to give all the pupils, as far as possible, an opportunity of gaining the experience of exercising them. The children thus learn the methods of government and obtain a realizing sense of its necessity, carrying away with them a permanent consciousness of their individual part and interest in its composition.

Under the customary system of school government, trespassers are regarded as culpable only when found out. The regulations being held as restrictions of liberty, infractions thereon are apt to be considered as nobody's business but the teacher's; any objections from a pupil are regarded as hostility, and any information concerning it is tabooed as "tattling." Under this system the child is apt to grow up with a sub-conscious sense of opposition to law and order, and at best with a feeling of indifference to it. This attitude of apathy continues in after-life and is prone to remain unaffected except when quickened by the touch of some immediate personal interest. The result is such as is frequently apparent in contemporary civic life, where large numbers of citizens remain indifferent to many civic affairs of general importance and leave these to be determined by others who have or seek in these affairs some

individual or private gain. The apathy and indifference from which these conditions arise are traceable in large measure to the unfamiliarity of the masses of the people with the machinery of government, and this ignorance the School City system is calculated to remove.

The School City method of teaching civics calls for the fullest recognition by all official Boards of Education, and it is almost self-evident that the system needs only to be carried out with a due measure of sympathetic encouragement and tactful supervision by the school principal and his or her assistants, to become an agency of far-reaching benefit in the sociological education of children. It furnishes a continuous object lesson in the science of government, inculcating at once the responsibilities and the duties of citizenship, and the ethical requirements of civic life. The pupils, instead of becoming imbued with a sense of antagonism to what is to them an arbitrary government, imposed by superior force, learn through their School City the value of the franchise and the importance of exercising it. Through ceasing to be subject to the exercise of power except as it expresses their own, they obtain a consciousness of personal dignity which is of utmost value in the upbuilding of character and which makes strongly for that ultimate aim of all true education, proper conduct in daily life.

It is but natural that the necessity for supplementing the tuition of common schools with lessons in the science and art of government, and also the invention born of that necessity, resulted first in our American democracy, where sovereign power is shared by every citizen. The need of this has been felt with increasing force for some time past. In 1888, the Patriotic League was organized under the presidency of Mr. Gill, with the co-operation of some of our leading publicists, for the purpose of fostering a healthier and more intelligent citizenship throughout the country, and his efforts in this direction gradually led to the development in 1896 of the School City system as it is now in use. While the first experiments with the School City method were being made by the inventor in New York City

in 1896–97 the League of Good Citizenship, a branch of the Civic Club of Philadelphia, was promoting a similar movement here. This took the form of branches of the League, organized in several of our Philadelphia schools, each branch subdivided into companies at the discretion of the principal. The companies meet once a month, under direction of a teacher, the meetings being designed to inculcate a proper regard for the regulations of the school and for the ordinances of the city. The system is under the charge of a committee of women and has been fruitful of good results.

There have not been wanting various other suggestions and experiments in this direction, such as the George Junior Republic, where a boys' reform school is organized as a self-governing community, and different modifications of the same idea in other institutions; but no comprehensive system of moral and civic training, adapted for use in common schools, preceded the introduction of the Gill School City. After the initial experiments in 1897, in several schools in New York, the system was introduced by discerning school principals in various cities of the country, and in 1898, by authority of the Board of Education of Philadelphia, the Hollingsworth Combined School in this city was organized on this plan, with the assistance of Mr. Gill. The system was at that time to have been extended to other of our local schools, but this was deferred through the originator being called by the Federal government to supervise the engrafting of his method on the school system of Cuba, then being organized under the military governorship of General Leonard Wood. The latter had become cognizant of the workings of the school city and deemed it of such importance for the educational system of the nascent Cuban republic that he determined on its adoption, and secured the services of Mr. Gill for the purpose. The School City was accordingly made part of the educational system organized in Cuba, and, as attested by some of its foremost citizens and leading educators, has quickly proven its value and efficiency. Latterly, since Mr. Gill's return from Cuba, at the request of the Secretary of War, to introduce his sys-

tem in the Philippines, and before his prospective departure, he has undertaken to complete in this city the work which was interrupted in 1898, and has now organized school cities in more than twenty of our public schools, to the eminent satisfaction of both teachers and pupils.

In the State Normal School at New Paltz, N. Y., where the School City has been in operation since early in 1900, the system has been developed to include the practice of various advanced principles of popular government, such as proportional representation, the initiative and the referendum, and has, moreover, been amplified into a school state, composed of a number of separate schools, thus putting in practice the processes of state and federal government. The possibilities of the system as a school of practice in the science and art of civic organization generally will be obvious without further detail.

The School City has been earnestly taken up in Great Britain, as is apparent from a recent work on Education by L. W. Williams, of Glasgow; it is being strongly urged for adoption in the public schools of France, and is being introduced into Mexico. Wherever the principles of parliamentary government hold sway, and especially where they are established on the foundation of popular sovereignty, as in our country, the necessity of training the electorate in the art of government is felt as a crying need of the present day, and as an imperative necessity of the immediate future. If the material well-being which has resulted from the gains of science and the arts is to be free from the dangers of a growth of civic apathy and the decay of civic virtue, and if the further progress of industrial development is not to be hampered and the normal evolution of our political and social system is not to be hindered and perhaps arrested by civic incapacity, then some adequate means of civic education must be applied. Hitherto our only constant reliance in this direction has been the public press, but this agency must as yet make its appeal to a body of citizens for the mass of which the art of government is but a vague, and at best, largely an academic proposition. Through the School City this and all other existing agencies of civic education

will be effectively reinforced by a practical training of the rising generation in the duties of civic life, imparted in the schools and during the years when culture and training have their most lasting effect.

In recognition of the great value and importance of the Gill School City system and of its usefulness as practically demonstrated, the Franklin Institute herewith awards to the originator, Wilson L. Gill, the Elliott Cresson Gold Medal and Diploma.

Attest: WM. H. WAHL,
Secretary.

PHILADELPHIA, June 1, 1903.

SOURCES OF RUBBER SUPPLY.

The Department of Agriculture has issued an interesting bulletin on rubber culture and production in the Central American States and the dependencies. The publication is the work of O. F. Cook, botanist in charge of tropical agriculture, who has made an exhaustive study of rubber culture in every field of production. Its importance appears from the fact that rubber is the third of the large imports from the tropics, sugar and coffee being the first and second respectively. The average value of the yearly importation of rubber is $28,000,000. These studies are directed primarily to the question whether rubber culture is promising for Porto Rico and the Philippines, and the principal fact established in this report, namely, that a continuously humid climate is neither essential nor even desirable for rubber culture, promises well for the extension of this industry to the tropical islands of the United States.

It is now accepted that rubber can be cultivated and that the supply from wild growths cannot be relied on for a sufficient amount from year to year. At the same time it has hardly been shown that cultivation is safe and profitable, and the whole industry may be said to be still in the experimental stage. It has been demonstrated that the Para tree may be cultivated interchangeably with the Castilla in Central America and Porto Rico, and is producing handsome results in the Malay Peninsula, Ceylon and Borneo. The variety of soils, exposures, altitudes and climates where Castilla will be successful have been found to embrace widely separated sources of supply. Mr. Cook commends rubber culture in the Philippines in view of what has been learned about Castilla.

Studies of Castilla in Mexico have resulted in a favorable opinion regarding the prospects of Castilla in Porto Rico since it is believed that the requirement of continuous heat and humidity has been over-stated. Mr. Cook says there are toward the southwest corner of the island many places where the climatic conditions are not unsuited for Castilla and where experimental plantings should be made.—*Electrical World.*

THE FRANKLIN INSTITUTE.

Read at the Stated Meeting, held Monday, November 18, 1903.

Decorated Stove Plate, 1764, from West of the Susquehanna.

By Prof. Charles F. Himes, Ph.D.

In the very interesting and valuable historical contribution of Professor Henry Mercer on "The Decorated Stove Plates of the Pennsylvania Germans," published by the Bucks County Historical Society, all the half-tone illustrations, twenty-three in number, are from castings made east of the Susquehanna. It is an interesting question not only when and where such castings were first made west of the Susquehanna, but also how they might be related in design and craftsmanship to those in the eastern part of the State. In the "Postscript" to the original paper Professor Mercer alludes very briefly, without illustration, to a plate which has an interesting bearing on this question. What seems to be a duplicate of the one alluded to has been added, recently, to the local historical collection at Carlisle, Pa.,* taken from the back of a fireplace.

It is about 24¼ x 27¼ inches, with a narrow flange all around, and bears the date "1764," and the words "Carlisle Furnace," and what is intended for the names Thornburgh and Sanderson, misspelled and clumsily executed. The design, on the other hand, of the twisted column, arch, and tulip pattern is well executed and bears such a marked general resemblance to *Fig. 16*, of the brochure alluded to, as to suggest identity. Inspection, however, soon shows variations in details; but the panel containing the name of the furnace, the figures of the date, and some other details seem, so far as comparison with a half-tone instead of the original will permit, to justify the inference of identity of portions of

* Presented to the Hamilton Library Association of Carlisle, Pa., by Miss Emma Aberle.

the mold, certainly of the caster. In regard to the "Delight of Warwick," as *Fig. 16* is named by Professor Mercer, he remarks that it is "half-German, half-English, the ill-spelled words *Iahn* (Johann) *Pot* (Potts) *and Warck Furnec* (John Potts and Warwick Furnace), and the German legend '*Las den Besen und thue Gutes*' (eschew evil and do good), betray the handiwork of a German designer working at the Warwick Furnace, near Pottstown, Pa., in 1764." He suggests that one or more German casters, finding employment from

Decorated stove-plate, Cumberland County, Pa., 1764. (Original, 24¼ x 27¼ inches.)

time to time at Warwick and Durham furnaces, carried their wooden molds with them. The point of peculiar interest in connection with the Carlisle casting is that it seems to carry the influence of the early Pennsylvania German artistic craftsmen to this then remote point west of the Susquehanna, and into a community not regarded as belonging to the German portion of the State, and to a furnace non-German in its origin and control, possibly the first fur-

nace, or at least as early as any, west of the Susquehanna. There was a bloomery and forge at Spring Grove, York County, as early as 1756, and Mary Ann Furnace at that place was erected on land leased for that purpose in 1762 by Geo. Ross (one of the signers) and Mark Burd. This furnace is suggested by James M. Swank, Secretary of the American Iron and Steel Association, as the first furnace in Pennsylvania west of the Susquehanna, as noted in Gibson's "History of York County." The Carlisle Furnace, however, better known in the accounts of it as the Carlisle Iron Works, located at Boiling Springs, on the Yellow Breeches Creek, in Cumberland County, was erected by John Rigbey & Co., on land patented by Richard Peters in 1762 and conveyed to them on the day following, and of which they were already in possession, and on which they had commenced the erection of a furnace. In 1764 the property was conveyed to a firm of six members, five from Philadelphia, one of whom was Robert Thornberg, and another, Francis Sanderson, of Carlisle. It was these latter names that the caster endeavored very awkwardly to introduce, transposing the "*r*" and "*u*" in Thornburg, inserting an "*e*" before the "*a*" in Sanderson, and so crowding it as to render it liable to be mistaken for an "*f*." In "Carlisle" the "*s*" and "*l*' have also been transposed. The substitution of the names of members of the firm in the place of the usual religious legend, in German, is regarded by Professor Mercer as an evidence of artistic decline. But when we consider that a German legend would not have been appreciated, perhaps even not enjoyed, by the Scotch-Irish dominant in that region, the omission hardly justifies such conclusion any more than does the awkwardness in execution of the English names. The "curious sundial-like medallion," to use the term employed by Professor Mercer, repeated on many of these plates, in the upper left-hand corner of this one, suggests a legend or motto, but, if so, it has eluded all efforts thus far to decipher it in this example.

DRYING COAL.

The very successful application of coal-dust firing to the burning of cement in rotary kilns and the extensive use that this system is now finding in the American cement industry direct attention to the means for pulverizing the coal to the required degree of fineness In order to pulverize coal economically and satisfactorily, it should not contain more than 1 per cent. moisture. The pulverizing capacity of a mill is nearly twice greater with coal containing only 1 per cent. moisture than with coal containing 2 per cent. This subject was discussed by C. O. Bartlett in a paper read at the recent meeting of the American Mining Congress at Deadwood, S. D. The moisture must be expelled from the coal without causing the coal to lose any of its volatile combustible. Two lots of coal will rarely dry alike, some coals giving up their moisture easily and freely, and others with difficulty. It appears that coals in which the ash is composed largely of silica dry easily and thoroughly, while those of which the ash is high in lime or clay are difficult to dry. It is very important to handle the coal in such a way that warm air in large quantity be brought in contact with every particle of it, which is best accomplished by passing the current of air from the dried material through that which is wet. It is never safe to pass the fire-gases through the drying coal. The ignition temperature of coals is variable, as is also the temperature at which they will give off their volatile combustible. In general, coal can be safely delivered from the dryer at about 150° F. without loss of gases, at 225° F. there is likely to be a small loss of gas, and that temperature cannot be recommended as good practice. It is necessary to use a fan blast to produce a sufficient current of air to carry off the moisture. This will carry off 3 to 5 per cent. of coal dust, which should be saved by passing the current into a brick-dust settling chamber, the walls of which will retain sufficient heat to prevent the moisture from condensing.—*Engineering and Mining Journal.*

ARTIFICIAL GRAPHITE AND SILICON.

Mr. FitzGerald, in a recent address, makes the following references to the production of graphite and metallic silicon in the electric furnace:

Very early in the manufacture of carborundum Mr. Acheson observed that when he heated his furnaces to an excessively high temperature the carborundum was decomposed, the silicon going off as vapor which burnt outside the furnace, or condensed in the cooler parts, while the carbon remained behind as graphite. This gave him the clue to a general method of manufacturing graphite from amorphous carbon by the decomposition of carbides. This has been developed into a successful business for the manufacture of graphite electrodes, which find a large use in electro metallurgical and electro-chemical processes; also for the production of graphite for use as paint pigment, lubricants, etc.

As regards silicon, a process has been developed for its manufacture. Hitherto silicon, in spite of the fact that it is one of the most widely distributed elements, has only been obtained pure with great difficulty; but now it can be manufactured at a comparatively reasonable price, and will no doubt form a valuable commercial product for the manufacture of silicon alloys and other purposes.

CHEMICAL SECTION.

Stated Meeting, held Thursday, October 15, 1903.

Catechu.

By W. E. Ridenour.

Catechu is known in the American market chiefly as cutch, without any modifying terms.

The mat, bag, and box, cutches mentioned in Fluckiger's Pharmacographia, are not at present found in commerce.

Difficulty was experienced to secure samples characteristic of the American importations. It was quite easy to get samples, but their origin could not be ascertained.

In buying cutch, samples and prices are submitted. You take your choice. The next time you wish to purchase, it is very uncertain that you can get the same quality as before. This is one of the points that has discouraged its use.

Brokers in dye-stuffs who formerly handled large quantities now practically carry none in stock.

Cutch or catechu ("Census Bulletin," No. 210) is obtained from the wood and pods of the acacia catechu and from the betel nut, both being native in India. Cutch appears in commerce in dark-brown lumps, which forms a dark-brown solution with water. It contains catechu-tannic acid as tannin and catechin and is extensively used in weighing black silks, as a mordant for certain basic coal-tar dyes, as a brown dye on cotton, and for calico printing.

The United States Pharmacopœia, 1890, only recognizes an extract prepared from the wood of Acacia Catechu, and gives the following tests:

If a portion of catechu be digested with ten times its weight of alcohol, and the liquid filtered, the undissolved matter after being dried at 100° C. should not exceed 15 per cent. of the original weight.

The tincture diluted with 100 parts of water acquires a green color on the addition of ferric chloride T. S.

Upon incineration, catechu should not leave more than 6 per cent. of ash.

M. de Meyer (*Journ. de Pharm.*, 1870) affirms that the best method of detecting adulteration of catechu is to treat the drug with ether. Catechu of good quality, after repeated treatment with ether, loses 50 per cent. of its weight.

Ether extracts from cutch, catechin.

Allen's "Commercial Organic Analysis," vol. iii, part 1, in addition to the above tests, gives color reactions of aqueous solution of catechu with various chemicals.

Sadtler's "Industrial Organic Chemistry" gives the following tests for valuing cutch:

Catechu Extract.—Catechu is frequently adulterated, not only with mineral matter like sand and clay, but with starch, dextrin, sugar, blood, etc. The mineral matters will, of course, remain in the ash. This in normal catechu should not exceed 5 per cent. The starch may be detected by extracting the sample with alcohol, boiling the insoluble residue with water, and testing the cooled liquid with iodine, which will show by the blue color any starch present. An addition of alcohol to the aqueous solution will show by the production of a turbidity any notable quantity of dextrin. Blood may be detected by treating the sample with alcohol, and drying and heating the residue in a tube, when the ammonia and offensive decomposition products will be given off, or the coagulation of the blood albumen when the aqueous solution is boiled.

The value of catechu for dyeing purposes can only be determined by a dye test. For this purpose strips of cotton-stuff are immersed for half an hour in a catechu solution (for each gram of the cotton 50 cubic centimeters of a catechu solution containing 5 grams to the liter of water are taken and diluted with water if necessary). The strips are pressed out, and then the color developed by oxidizing in a hot solution of 1 to 2 grams of potassium bichromate to the liter of water.

A. Jossart (*Jour. Pharm. d'Anvers*, 1881) examined a catechu which was adulterated with 65 per cent. of ferrous carbonate.

Several samples of cutch were collected from various

sources and submitted to the most important of the above tests. In addition to the dyeing test on cotton given by Sadtler, the same test was made, using strips of silk, which gave more pronounced colors. Also the solvent action upon cutch of several liquids was determined with the following results:

	Samples Marked.	Ash.	Starch.	Blood.	Color with Ferric Chloride.	Tannin.	Dextrin.
	A. & D., before being Pr.	3·6	—	—	Brown Green No Ppt	40·0	Heavy
	A. & D., new lot	6·8	—	—	Brown Green Ppt.	49·6	—
	A. & D., Bell brand	3·5	—	—	Brown Green and Ppt.	67·6	—
No. 1.	Liverpool, Woodward . . .	3·9	—	—	Green and Ppt.	36·0	—
No. 2.	Liverpool, Woodward . .	6·1	—	—	Brown and Ppt.	58·8	—
	Philadelphia	·4	—	—	Brown and Ppt.	72·8	—
	A. & D., high grade	4·2	—	—	Green Ppt.	62 8	—
	8418, Scharunpoor, India .	4·3	—	—	Green	41.6	—
	8417, Scharunpoor, India .	3·9	—	—	Green	44.0	Trace
	9919, No. West Prov., India	10·1	—	—	Green	35·6	—
F.	3615, Pondicherry, India . .	58 5	Heavy	—	—	·8	—
	8569, Scharunpoor, India .	1·2	—	—	Brown Green	34·8	Heavy
	McK. & R., Catechu	2·7	—	—	Brown Green	34·4	—
	McK. & R., Terra Japonica	4 6	—	—	Green	25·6	—
	S. D. & E. Co. —— A.	1·5	—	—	Brown Green	28·4	Heavy
	S. D. & E. Co. —— B.	11·7	—	—	Brown Green	22 8	Heavy
	P. C. P. Acacia Catechu . .	1·8	—	—	Brown Green	30·8	Heavy
	Immedial Cutch —— G.	60·1	—	—	—	—	—
	Immedial Cutch —— O.	60·3	—	—	—	—	—
J. R.	Straits Settlement, Port of Shipment, Singapore — Woodward, Liverpool . .	6·5	—	Slight Odor	Brown	2·4	—

	Samples Marked.	Hot Ethyl Alcohol.	Ether.	Acetone.	Paradehyde.	Fusel Oil.	Purified Methyl Alcohol.	Water.
	A. & D., before being Pr. .	60·1	10·6	54·9	14·2	57·5	64·7	79·6
	A. & D., new lot	31·7	·4	2·5	1·6	6·0	55·9	82.0
	A. & D., Bell brand	83·5	·7	38·4	6·0	16·2	86·4	87·6
No. 1.	Liverpool, Woodward . . .	39·0	1·3	5·1	2·5	13·2	47·6	72·8
No. 2.	Liverpool, Woodward . . .	50·6	·3	17·2	·6	11·3	81·5	89·2
	Philadelphia	87·2	6·0	83·5	2·1	82·6	86·2	88·8
	A. & D., highlgrade	70·1	2·0	62·5	1·1	21 9	79·6	82 8
	8418, Scharunpoor, India .	80·6	21·2	81·0	13·8	88·5	77 4	75·6
	8417, Scharunpoor, India .	75.2	36·4	71·4	24·2	83·8	70·0	82·8
	9919, No. West Prov., India	62·4	23·6	59·6	32 0	64·4	69·2	70·4
F.	3615, Pondicherry, India . .	9·8	3·8	5·6	4·8	11·8	12·8	14·4
	8569, Scharunpoor, India	62·0	12·2	53·2	12·2	62·0	68·4	88·8
	McK. & R., Catechu	57·2	·6	7 0	2·0	16·8	60 2	74·0
	McK. & R., Terra Japonica	66·4	27 2	56·0	7·4	64·8	72·6	76·0
	S. D. & E. Co. —— A.	62·6	31·0	58·4	19·0	75·8	65·4	86·0
	S. D. & E. Co. —— B.	40·0	13 0	32·0	8·6	53·0	41 4	72·4
	P. C. P. Acacia Catechu . .	61·6	18·2	50·6	11·8	62·4	64·2	83·6
	Immedial Cutch —— G.	—	—	—	—	—	—	—
	Immedial Cutch —— O.	—	—	—	—	—	—	—
J. R.	Straits Settlement, Port of Shipment Singapore — Woodward, Liverpool . .	53·2	·8	14·4	·4	19·4	81·0	92·0

Solubility.—·500 grams of the finely powdered sample are digested over night in 15 cubic centimeters of the solvent. The liquid is filtered through paper into a tarred dish, and the residue treated with two successive portions of the solvent, 15 cubic centimeters each. The combined filtrates are evaporated to dryness and the residue dried to a constant weight at 100° C. in an air-bath.

The hot alcohol extraction gives the most uniform and concordant results; approximating the tannin contents. But it is no criterion of the dyeing value, as the highest alcoholic soluble samples give the lightest colors on cotton and silk. The estimation of tannin also gives no indication

of its dyeing value, as the samples highest in tannin value dye the lightest colors.

The hide-powder method was used exclusively for the estimation of the tannin.

The methyl alcohol results agree very closely to those obtained with ethyl alcohol, hot extraction, and there is no reason why methyl alcohol cannot be substituted for the latter.

The other solvents are unsatisfactory in their action. The results do not agree with those obtained with either ethyl or methyl alcohols or the tannin contents.

Chloroform extracts nothing from catechu and for this reason is omitted from the tables.

The solvent action of acetone upon the various samples of cutch is very strange and some of the results are impossible to explain, *i. e.*, in samples A. and D., new lot, Liverpool No. 1, Liverpool No. 2, and McK. & R. catechu, the acetone soluble portion is very much smaller than the percentage of tannin.

Henry Trimble ("The Tannins," vol. ii) states that acetone has been found very valuable for the extraction of the oak tannins.

My own experience has shown that acetone extracts tannin from Aleppo and Chinese galls very thoroughly, and yet it seems to have a selective action upon the tannin in different samples of catechu.

The sample marked Philadelphia is the only one that answers all the requirements of the United States Pharmacopœia.

The percentage soluble in ether in all samples examined is much below the standard recommended by M. de Meyer. The value of this test is much to be doubted, as ether dissolves the catechin, then samples of catechu containing 50 per cent. or more of tannin cannot answer this test.

The ash is as a rule much lower than 6 per cent. Those of higher percentage indicate intentional adulteration.

Sample 3615 is a mixture of clay, starch and organic coloring matter. Samples Immedial Cutch G. & O. are mixtures of sodium and potassium, chloride, sulphide, and

sulphate with an aniline dye. The manufacturer claims they are neither natural nor synthetic.

The ash of sample J. R. is very little in excess of U.S.P. requirement, but 2·3 per cent. is sodium carbonate.

Sample J. R. is a puzzle. The ash is not excessive.

The ethyl alcohol and methyl alcohol solubles are good and the dye test very good, but the percentage of tannin present in the sample is abnormally low; also there is one strange reaction which did not occur with any other sample; the water solution of the residue from the alcohol extraction, which was of a very deep red color, gave a heavy precipitate with Iodine T. S. and a colorless liquid.

Sample P.C.P. Acacia Catechu is from the museum of the Philadelphia College of Pharmacy and is at least twenty years old.

Samples 8418, 8417, 9919, 3615, 8569 are from the Philadelphia Commercial Museum.

Sample J. R. is from Mr. T. B. Woodward, Liverpool, Eng., from whose letter I quote: "It is a production from the Straits Settlement and the port of shipment is Singapore. The brand is J. R. It is the strongest in tannin of all the cutches, and indeed is the strongest in tannin of any extract yet produced. Though it does not suit many dyers who require cutches giving a yellower shade of brown, it is still very largely used for dyeing silk and cotton goods. My largest sale for it, however, is for tanning mackerel and herring fishing nets, sails, and fishing lines. The object is to preserve the fishing gear, which it does more efficiently than any other agent I know. Some of the telegraphic construction companies use it extensively for preserving the fiber used in the construction of their cables. The reddish color it gives does not please our tanners, who are extremely conservative and hard to move."

There are, therefore, two distinct methods of examining cutch, according to what uses are to be made of it. If for tanning or medicinal purposes, then the ash, ethyl or methyl alcohol soluble and tannin should be estimated; if for dyeing purposes, then only a practical dye test can decide.

To what principle in catechu is the dyeing value due?

Five grammes of cutch are dissolved in one liter of hot water, allowed to cool and filtered.

This solution is detannated by passing through hide-powder, the percolate giving no precipitate with tannic acid or a color with ferric chloride. A strip of silk, dyed in this solution, which was of a deep red color, and developed with potassium bichromate, gives very little color, quite a contrast with silk dyed with original catechu.

Five grammes of the purified tannin are then dissolved in one liter of water and a strip of silk dyed under the same conditions gives a deeper color than that developed by using the original catechu.

Preparation and Purification of Tannin from Catechu:—Extract the powdered cutch with acetone, and evaporate the clear liquid to dryness; dissolve the residue in hot water, allow to cool and add water until it ceases to give a precipitate. The clear filtrate is shaken with ether to remove catechin, and then the tannin is removed by agitation with successive portions of acetic ether. The acetic ether is recovered, the residue dissolved in water and diluted until it ceases to give a precipitate, and the clear filtrate agitated with acetic ether; this process of solution in water and shaking out with acetic ether is repeated until the tannin is completely soluble in water.

The tannin is then dissolved in a mixture of alcohol and ether, filtered, and then evaporated to dryness under reduced pressure, which gives the tannin in a porous condition.

Properties:—Catechu tannin, as prepared by the above process, is of a reddish-brown color, and completely soluble in water and alcohol.

Ether containing alcohol and water dissolves it, but stronger ether has little solvent action.

A 1 per cent. solution of this tannin in water gives the following reactions:

Ferric chloride,	Dirty green ppt.
Ferrous sulphate	No change.
Lead acetate	Whitish ppt.
Potassium bichromate,	Red-brown ppt.
Ferric acetate	Olive-green ppt.

The reactions are practically those of all tannins which give green precipitates with ferric salts; to the same class belong the tannins from mangrove, canaigre, hemlock, rhatany and the oaks.

MEASUREMENTS OF RADIO-ACTIVITY.

In newspaper references to the gift of radium recently made to the New York Museum of Natural History by Mr. E. D. Adams, the activity of the material was expressed in numbers, with no explanation of the manner in which the numbers were determined. In the paper read by Mr. Hammer in April before the American Institute of Electrical Engineers and the American Electro-chemical Society, which in part treated of radium, this explanation appears.

To measure radio-activity, Prof. and Mme. Curie measure the electric conductivity which a radio-active substance imparts to air, and take as unit the radio-activity of uranium. The radio-active substance is placed on one of two condenser plates, which are charged to a high potential. The air between the condenser plates is rendered a conductor of electricity by the presence of the radio-active substance, and in a certain time a certain quantity of electricity will pass from this condenser plate to the other plate. This quantity of electricity passing over in a certain time is determined and serves as a measurement of radio-activity. If the quantity of electricity passing from one plate to the other in a certain time is x times the quantity which would pass in the same time if uranium was substituted for the tested radio active substance, it is said that the latter has the radio-activity x. The problem is, therefore, to measure the quantity of electricity passing from the one condenser plate to the other in a certain time. This may be done in two essentially different ways. Either by an electrometer method the quantity of electricity may be measured which during a given time passes over to the previously uncharged condenser plate. Or the time may be measured in which this plate when connected to an original charged gold leaf electroscope discharges it. For these latter measurements the gold leaf electroscope may be observed by means of a telescope provided with a micrometer scale and the time taken for the discharge of the electroscope is taken by means of a chronometer. By such methods, the Curies say, according to Mr. Hammer, that they can detect the presence of a radio-active substance in so minute a quantity that it would require 5,000 times this amount to show at all in the spectroscope. And it is stated that this method of electrical analysis is thousands of times more sensitive than spectrum analysis and millions of times more sensitive than chemical analysis.—*Electrical World.*

LIQUID HYDROGEN.

Olszewski describes in the Cracow *Bulletin* a new apparatus for the liquefaction of hydrogen, differing from his previous models in having both regenerators and the intermediate cooler for receiving liquid air all placed in a common vacuum chamber. The apparatus is said to work faultlessly.

CHEMICAL SECTION.

Stated Meeting, held Thursday, March 19, 1903.

What Physical Chemistry has Done for Chemistry.

By Harry C. Jones.

[ABSTRACT.]

Physical chemistry has furnished us with several generalizations which have greatly modified our methods of dealing with chemical phenomena. Among these may be cited the Theory of Electrolytic Dissociation, the Law of Mass Action, Faraday's Law, the basis of chemical valence, and the Phase Rule.

Of these generalizations time will permit us to consider only one or two, and we can only make a few applications of the most important of them all—the Theory of Electrolytic Dissociation.

A word or two in reference to the origin of the theory.

Osmotic Pressure.—When a solution of any substance is brought in contact with the pure solvent, or with a solution of different concentration, at the surface of contact of the two solutions there exists a pressure which tends to drive the dissolved substance from the region of greater to the region of lesser concentration. This is known as osmotic pressure.

The first to measure the magnitude of this pressure was the botanist Wilhelm Pfeffer, who found that salts gave a greater osmotic pressure, for equivalent concentrations, than solutions of substances like cane sugar.

Origin of the Theory of Electrolytic Dissociation.—It remained for Van't Hoff to point out that the electrolytes in general—acids, bases, and salts—exerted a greater osmotic pressure than the non-electrolytes. He also showed that osmotic pressure is a property which depends only upon the *number of parts* of the dissolved substance in a given volume of the solvent, and not upon the nature of the parts. Since osmotic

pressure depends only upon the ratio between the number of parts of the dissolved substance and the number of parts of the solvent, and since electrolytes exert an osmotic pressure that is greater than can be accounted for on the basis of the existence of these substances in the molecular condition, we are forced to the conclusion that the molecules of electrolytes are broken down in solution into parts. These part molecules are called *ions*.

I cannot take up here the evidence bearing upon the theory of electrolytic dissociation, since it would lead much too far. Suffice it to say that the experimental evidence, as far as it has been established in a trustworthy manner, is practically unanimously in favor of the theory, and the amount of such evidence already at hand is simply overwhelming. The theory of electrolytic dissociation is as well established as most of our laws in science, and is to-day almost universally accepted by the leading chemists and physical chemists throughout the world.

Neutralization of Acids and Bases.—Let us now see what the theory has done for chemistry. Here again we can take up only a few of the many applications of this most important generalization. Take a class of chemical reactions that are more or less familiar to every one—the neutralization of acids and bases. It has long been known that when an acid is brought in contact with a base, both are neutralized, and when the solution is evaporated a salt is obtained. Since a different salt was obtained with every acid and base employed, we had as many new phases of the problem of neutralization as we had acids and bases to react.

This whole subject has been beautifully unified and simplified by means of our theory. Take the neutralization of hydrochloric acid with sodium hydroxide. Hydrochloric acid in dilute solution is a mixture of hydrogen ions and chlorine ions:

$$HCl = \overset{+}{H}, \overset{-}{Cl}.$$

Sodium hydroxide in dilute solution is a mixture of sodium ions and hydroxyl ions:

$$NaOH = \overset{+}{Na}, \overset{-}{OH}.$$

When these solutions are brought together we have:

$$\bar{Cl}, \overset{+}{H} + \bar{OH}, Na = \overset{+}{Na}, \bar{Cl} + H_2O.$$

What takes place and all that takes place in the above case is the union of the hydrogen ion of the acid with the hydroxyl ion of the base, forming a molecule of water. The anion of the acid, chlorine, and the cation of the base, sodium, remain after the process of neutralization in exactly the same condition as before neutralization took place, and a salt is formed only when the solvent which dissociated the salt into its ions is removed. We may now discuss the subject of neutralization in general. We may represent any acid by—

$$\bar{R}, \overset{+}{H}, \text{ where } \bar{R}$$

is the anion, which differs in composition for every acid, and the cation hydrogen which is common to every acid. Similarly, we may represent any base by—

$$\overset{+}{R}, \bar{OH}, \text{ where } \overset{+}{R}$$

is the cation of the base. Its composition varying with every base, and hydroxyl is the anion common to all bases. When any base reacts with any acid, we have:

$$\bar{R}, \overset{+}{H} + \bar{OH}, \overset{+}{R} = \bar{R}, \overset{+}{R} + H_2O.$$

Water is always formed, and the anion of the acid $\bar{R}$, and the cation of the base $\overset{+}{R}$, remain in the solution after the process of neutralization in exactly the same condition as before neutralization took place. In order to obtain the salt the water which holds the ions apart must be removed.

Neutralization, then, in terms of our theory consists in the formation of a molecule of water from a molecule of the acid and a molecule of the base, and in nothing else. One process of neutralization is, therefore, exactly the same as any other process of neutralization, regardless of the nature of the acid or the nature of the base involved. If this is true it is very important, since it refers all the processes of neutralization to a common cause—the union of the hydrogen ion of the acid with the hydroxyl ion of the base.

Heat of Neutralization.—We have a means of testing this crucially by experiment. If the process of neutralization is independent of the nature of the acid and the nature of the base, the amount of heat set free when any completely dissociated acid acts on any completely dissociated base in equivalent quantities, will be a constant.

The fact is that a *constant amount of heat* (13,700 cals. is liberated when a gram-equivalent weight of any completely dissociated acid is brought in contact with a gram-equivalent weight of a completely dissociated base. A few examples will make this clear:

HCl	$+ NaOH$	$=$	13,700 cals.
HNO_3	$+ NaOH$	$=$	13,700 cals.
$HClO_3$	$+ NaOH$	$=$	13,600 cals.
KOH	$+ HCl$	$=$	13,700 cals.
$LiOH$	$+ HCl$	$=$	13,700 cals.
$\frac{1}{2} Ca(OH)_2$	$+ HCl$	$=$	13 900 cals.

If we vary the nature of the acid or the nature of the base, the amount of heat set free is a constant to within the limit of experimental error. Fact and theory are thus in perfect accord.

Thermoneutrality of Salts.—Another application of the theory of electrolytic dissociation in thermochemistry is interesting and important. It has long been known that when dilute solutions of neutral salts are mixed there is no thermal change—heat is neither liberated nor absorbed. This is the well-known law of the thermoneutrality of salts. While the fact was established beyond question, and various suggestions had been made to account for it, it was generally conceded that no one of these was at all satisfactory. The explanation to-day is very simple. Take the two salts, potassium chloride and sodium nitrate; a dilute, aqueous solution of potassium chloride contains only potassium ions and chlorine ions; a dilute solution of sodium nitrate contains sodium ions and nitric ions.

$$KCl = \overset{+}{K}, \overset{-}{Cl}$$
$$NaNO_3 = \overset{+}{Na}, \overset{-}{NO_3}$$

When the two solutions are mixed we have in the mixture potassium and sodium cations and chlorine and nitric anions, and nothing else. In a word, we have exactly the same ions in the mixture as in the solutions before they were mixed. There being no chemical change, there should be no thermal change, and such is the fact. The law of the thermoneutrality of salts could have been predicted from the theory of electrolytic dissociation, had it not been discovered long before the theory was discovered.

Color of Solutions.—Another class of chemical phenomena which had long attracted attention, but the significance of which was not clearly understood, was the color of substances, especially when in solution. Take, as an example, the color of the permanganates. The salts of permanganic acid with the alkalies and alkaline earths all have apparently the same color, which is the color of permanganic acid itself. This was tested quantitatively by Ostwald, who photographed the absorption spectra of these and other permanganates where the cation was colorless, and showed that they all had exactly the same absorption bands. We can see at once the explanation of this fact. Permanganic acid dissociates thus:

$$\overset{+}{H},\ \overset{-}{MnO_4}.$$

The color of the solution is not due to the hydrogen ions, since there are hydrogen ions in solutions of all acids and solutions of most acids are colorless. The color of the solution of permanganic acid must be due to the presence of the permanganic ion:

$$\overset{-}{MnO_4}.$$

The color of the solution of any permanganate in which the cation is colorless, is due to the ion:

$$\overset{-}{MnO_4}.$$

This can be seen at once, when we remember that any permanganate can be represented by the formula:

$$RMnO_4.$$

in which R is a metal which yields a colorless cation. This compound would dissociate thus:

$$RMnO_4 = \overset{+}{R}, \overset{-}{MnO_4}$$

$\overset{+}{R}$ being colorless, the color of the solution must depend upon the colored ion:

$$\overset{-}{MnO_4}.$$

We thus see at once why all such salts of permanganic acid must have exactly the same color.

Ostwald studied in all about 300 colored compounds, and found the theory of electrolytic dissociation most helpful in explaining phenomena similar to the above.

Modes of Ion Formation.—We have spoken thus far of molecules breaking down into ions in the presence of a dissociating solvent—

$$HCl = \overset{+}{H}, \overset{-}{Cl}$$

$$KOH = \overset{+}{K}, \overset{-}{OH}$$

$$KCl = \overset{+}{K}, \overset{-}{Cl}$$

It must, however, not be concluded that this is the only way in which ions can be formed from molecules.

We may have one metal precipitated from a solution of one of its salts by another metal. When a bar of zinc is immersed in a solution of a copper salt, the zinc passes into solution and the copper is thrown out of solution. What takes place here is a transference of the electrical charge from the copper to the zinc. The copper having lost its charge, passes out of solution, while the zinc, having become an ion, passes into solution. This is obviously a mode of ion formation.

There are still other modes of ion formation. Take a bar of gold and dip it into chlorine water. Neither the gold nor the chlorine is in the ionic state before they come in contact. When they come in contact the gold becomes cationic and passes into solution, while the chlorine remains in solution, but passes from the molecular into the anionic condition. We have both cations and anions formed under conditions

which are usually described as the solution of gold in chlorine water.

Solutions of Metals in Acids.—There are few chemical processes with which we are more familiar than the solution of metals in acids. Most metals dissolve in the strong acids, and from such solutions salts of the metals can be obtained on evaporation. This fact, which has been so long known, has only recently been satisfactorily explained. An acid dissociates, always yielding hydrogen ions, and anions whose nature depends upon the acid in question. This may be represented in general as follows:

$$HR = \overset{+}{H}, \overset{-}{R}$$

When such an acid is brought in contact with a metal the hydrogen ions of the acid give up their charge to the metal, and escape as hydrogen gas. The metal, having taken the charge, passes into solution in the ionic state. This is a perfectly general process, independent of the nature of the acid and independent in general of the nature of the metal. In reality it is a mode of ion formation. An ion which holds its charge less firmly—hydrogen—giving it up to the metal which holds the charge more firmly, the hydrogen escaping in the gaseous condition, the metal passing into solution.

Hydrolytic Dissociation.—Thus far the subject of electrolytic dissociation, or the breaking down of molecules into ions, has been considered. There is another kind of dissociation, which takes place in solutions of certain chemical compounds. When an alkali salt of a weak acid like carbonic acid is brought into the presence of water it shows an alkaline reaction. The fact has long been known, but no satisfactory explanation of it has been furnished. We have to-day a perfectly rational explanation of these and similar facts. There is at first a chemical reaction between the salt and the water, which takes place in the sense of the following equation:

$$K_2CO_3 + H_2O = KOH + KHCO_3.$$

This is known as *hydrolytic dissociation.* As soon at the pro-

ducts of hydrolytic dissociation are formed they are electrolytically dissociated by the water. In the above case the following ions are formed:

$$KOH = \overset{+}{K}, \overset{-}{OH}.$$

$$KHCO_3 = \overset{+}{K}, \overset{-}{HCO_3}.$$

The hydroxyl ions from the dissociated water give the alkaline reaction, which is characteristic of such solutions.

We can thus see why the salts of weak acids react alkaline, and in a similar manner can understand why the salts of weak bases react acid. They are hydrolytically dissociated by water yielding the free acid, which then dissociates yielding hydrogen ions, which give the characteristic reaction to the solution.

Faraday's Law the Basis of Valence.—The lecturer then took up a discussion of Faraday's law as the basis of chemical valence. He pointed out that if we refer valence to the law of Faraday we place it upon an exact physical basis. If we do not, the name valence is more or less indefinite, being used with a great variety of meanings.

Importance of Energy Changes for Chemistry.—The lecture concluded with a plea for the necessity of dealing with the energy changes which take place when substances react chemically. Hitherto we have regarded these energy changes as subordinate, and have referred to chemical reactions as being accompanied by thermal change. This is confusing cause and effect. It would probably be much nearer the truth to say that thermal changes are accompanied by material transformations.

It was then pointed out that by studying material transformations alone we can never have an *exact science of chemistry*. This can be realized only by studying together with the products of the reaction, the thermal changes, the electrical changes, the light changes; in a word, the reciprocal transformations of intrinsic and other forms of energy.

ELECTRICAL SECTION.

Stated Meeting, held May 28, 1903.

Static Discharges in Electric Circuits.

By Percy H. Thomas.

(*Concluded from page 398.*)

Partial Reflection.—There are other important cases of reflection in addition to those already treated. Suppose the medium or wire, instead of terminating absolutely as assumed above, changes to another "stiffer" medium or smaller wire in which the wave can continue. By stiffer medium is meant one of comparatively larger inertia and smaller elasticity. It is evident that on account of its smaller elasticity or capacity the whole energy of the wave cannot pass into the smaller section without an increase of intensity, but any increase of intensity must cause a portion of the wave to be reflected backward toward the source; that is, the original wave will divide into two parts, a portion going forward into the new medium, a portion going backward, and there will be a rise of potential at the reflecting point less than the double potential which is produced by complete reflection. The more rigid, that is, the smaller the capacity of the second portion of the line, the larger the portion of the original wave which will be reflected. It must be noticed, however, that the portion of the wave passing into the more rigid medium has as its initial voltage the voltage produced at the reflecting point by the original wave which is higher than the latter. As a consesequence, if the wave in the second portion of the line be itself afterward reflected, a rise of potential may occur greater than double the original wave. Similarly a still greater rise of intensity will occur with the passage of the second wave into a third medium more rigid than the second.

On the other hand, if the medium branch into two parts,

each similar to the original, the energy of the wave will be divided into two parts and the intensity of each reduced. At the same time there will usually be a portion of the wave reflected backward with change of sign toward the source as well as portions going forward into the two branch lines. In other words, partial reflection by changing to either a more or less rigid medium divides the energy of the wave, reducing the energy at any one point. If a wave divide into two parts to follow two similar lines of equal length, these partial waves may be reflected at the ends of the branch lines, and since the two lines are the same length, will return at the same time and unite their energy at the junction point and send a reinforced wave toward the generator.

Electric Waves.—So far the waves treated have been linear waves, such as are confined to tubes or wires, but have not been limited to any particular form of wave, as light, water or electricity. However, examples have been given more particularly with reference to electric waves. From this point on, electric waves only will be considered and electrical terms only will be used.

In the electric circuit "elasticity in the medium" is represented by capacity. The stiffer the medium the smaller the capacity.

Weight or inertia is represented by inductance, the greater the inductance the greater the inertia.

The quantity of static electricity corresponds to the intensity or displacement in the wave.

The velocity of motion of the wave along the line is inversely proportional to the $\sqrt{C\ L}$. In air lines this approximates roughly the velocity of light, viz., 186,000 miles per second.

On account of the great velocity of the electric wave the ordinary generator frequencies of 25 to 100 cycles per second are not sufficiently rapid to produce a perceptible difference in time between the action at the generator and the motor end of the line; there is, however, actually, a very small lag. That is, a commercial circuit acts for all practical power transmission as a rigid transmission system, *e. g.*,

a pair of gears. When, however, as by lightning disturbances, short-circuiting of line wires, or grounding of the circuit, a very sudden change of potential is produced, complete waves are produced in the line on account of the enormous frequency of such disturbances, and there is a great phase lag between the source and the end of the line. Any of these causes of abrupt change of potential are likely to be oscillatory, that is, cause an oscillation of potential at the discharge point backwards and forwards for a few periods. The number of such oscillations would, however, in commercial circuits, probably rarely exceed one-half dozen. These few, however, will send corresponding waves into the line, which may be reflected and may build up resonance or nodes and loops as conditions already described may determine.

It is these abrupt changes of potential not directly produced by the generator which for commercial circuits are properly designated by the term "Static Discharges." Their distinguishing characteristics is their extreme frequency of alternation, which is so high as to cause several complete waves to be formed in transmission lines of moderate length.

All the laws and properties of linear waves which have been here considered apply, of course, to these static electrical waves. For, example, static waves have their form and intensity determined by the nature of their source, that is, by the sort of change of potential at the point of the line where the exciting discharge occurs; and once formed each wave passes down the line without reference to what may subsequently occur at the source. This wave will preserve its form and intensity except for losses in the medium, here represented by the wire, or for complete or partial reflection. As before, complete reflection occurs either at an open-ended wire corresponding to an obstacle which produces as a maximum double potential at reflecting points and returns the wave towards the source without changing its sign; or, by a short circuit or very large condenser which prevents any rise of potential at the reflecting point, but returns the wave towards the source with its sign reversed. Partial

reflection occurs with every change in the quality of the medium. This quality is measured by the capacity and inductance. If at the reflecting point the capacity of the lines be increased or the inductance be diminished, the rigidity is decreased and the wave is partially reflected; and the portion entering the new part of the line has a less voltage than the original wave, if the capacity be decreased, or the inductance increased, the rigidity of the medium is increased, partial reflection will again occur and the portion of the wave entering the new line will have a higher potential than the original wave.

Stationary nodes and loops or resonance may occur in an electric line as in any other case of linear wave motion, the critical condition to cause their occurrence being a number of similar waves following one another at uniform intervals in case of either resonance or loops, and in addition exact adjustment of the length of the line to the frequency of the alternating source in the case of resonance.

Effect of Static Waves in Commercial Circuits.—The net results as regards the operation of commercial circuits may be indicated quite briefly. Whenever a line is connected to a live circuit, whenever a line is accidentally grounded, whenever a short circuit occurs between two lines, or a lightning arrester discharges, or in case of any similar disturbance, there occurs at the point a very abrupt change of potential either up or down. The exact abruptness of such a change depends upon the local conditions and constants of that portion of the circuit at which the discharge occurs. In actual cases it probably varies between $\frac{1}{10,000}$ part and $\frac{1}{10,000,000}$ part of a second for each alternation. It is evident that this discharge is enormously rapid in comparison with 25 to 100 cycles per second of the generator frequencies. The frequency of 1,000,000 periods per second would give a wave length to the static wave in a transmission line of approximately 1,000 feet. Usually the discharges resulting from switching, grounding, etc., are oscillatory, but not very persistent; that is, each oscillation of the discharge is considerably less intense than the previous one, and after perhaps half a dozen alternations they become too weak to be

serious. This means that no very high rises of potential will occur from resonance at these high frequencies, though a rise of two or three times the original potential might perhaps sometimes occur if conditions were very favorable. Usually, also, there will be a considerable diminution in the intensity of traveling waves, due to the fact that in their passage along the line they will suffer loss of energy from resistance and other losses, so that neither will double the original potential be produced by reflection, nor will the full values of the original waves be added together in case of resonance. This loss of energy in transmission will be especially effective in preventing a rise due to resonance since any increase in intensity of the wave greatly increases the losses in transmission.

To sum up, in commercial circuits, as a result of static disturbances, momentary rises of potential may be expected, more often at the ends of lines or other reflecting points, usually not over 50 per cent. greater than the abrupt change of potential which caused the wave; but in some cases where the length of line involved and other conditions are favorable for resonance a rise to two or three times the original voltage of the source may perhaps be found. There is, however, an additional phenomena which, apparently, somewhat increases the severity of these disturbances. This results from the heavy momentary charging current taken by a transmission line or other large capacity, when charged or discharged abruptly; this charging current tends to build up momentarily the voltage from which the line is being charged. Its effect is somewhat the same as would be experienced if the field strength of the generator were momentarily increased. This phenomena may add perhaps another 50 per cent. to the intensity of the static disturbance. These conclusions are based partly upon theoretical considerations, as indicated in the earlier part of the paper, and, at least as to the extent to which abnormal potentials may be expected in commercial circuits, partly upon a considerable number of actual tests which have been made by the writer in conjunction with the engineers of a number of large installations for the purpose of determining the

practical effect of such disturbances. These tests have extended over a considerable range of time and diversity of location and have included widely different voltages and different lengths of line running to over 100 miles. In all cases the results obtained have been in accordance with the conclusions above.

Lightning.—The disturbances produced by lightning have their maximum intensity determined by different conditions from the waves produced by internal disturbances in the transmission system itself. The former are evidently determined by the intensity and proximity of the lightning flash and the protective apparatus, while the latter are determined directly by the generator voltage. Ordinarily the actual line disturbances produced by lightning are not extremely severe, and with efficient arresters on high tension circuits may be considered as not exceeding those due to the other causes of static disturbance. In exceptional cases, however, where lines are directly struck by lightning discharges of greater or less magnitude, there is an extreme rise of potential locally on the transmission line which is beyond the power of any commercial arrester to prevent. Fortunately, however, this discharge seeks the earth by the shortest path and will usually choose one or more line poles in the immediate vicinity of the discharge. Such poles will sometimes be chipped or split and sometimes completely splintered. This discharge may or may not cause a short circuit on the line; frequently will not. Although the main discharge reaches ground in all probability close by the point struck, there will, of necessity, as already explained, be waves sent in both directions down the line wires which will have an extreme maximum intensity at the start and which may do serious damage at the stations; but which are of a magnitude that may properly be handled by protective apparatus. Thus, though the direct violence of the stroke cannot be guarded against or resisted, yet, except in the very rare case where such discharge is in the immediate neighborhood of the station, very often no harm will result, provided the station apparatus be protected by efficient arresters.

Sources of Static Waves.—The common sources of static

disturbance with the effects produced are summarized below.

(1) Charging a dead line from a live transformer not already supplying other lines, momentarily drops the potential of the transformer lead to zero; the generator then supplies charging current at a comparatively slow rate to bring the line to normal potential. In this case usually no wave will be produced, as the frequency is comparatively low. There may, however, result a certain momentary rise of potential.

(2) When a dead transmission line is charged from a system having a large quantity of electricity already stored in other lines connected to the same high tension bus bars, the potential of the new line is very suddenly raised to the potential of the system, and this sends an abrupt wave of positive sign along the line.

(3) Grounding or short-circuiting a charged line causes a sudden fall of potential, which sends a wave of negative sign along the line in both directions. This wave evidently causes no *rise* of potential at any point and is harmless except for a phenomena to be discussed later, under the head of Local Concentration.

(4) Opening a loaded line causes no rapid change of potential, since the load current produces a large volume of heated air, gradually cutting down the potential of the line.

(5) Opening an unloaded line has much the same effect as charging a line, since in opening the switch there will usually be a rapid charge and discharge of the line for a few alternations. That is, the instant after the line is free from the switch for the first time, the next alternation (being of opposite sign) will frequently be able to jump the gap and recharge the line momentarily, thus causing a static spark; that is, positive waves will be sent down the line.

Fortunately these potential rises are momentary and do not produce as severe a strain upon solid insulating material as similar potentials of long-continued duration. This results probably from the heat and mechanical inertia of the insulating material. Therefore, solid insulating material which is sufficiently strong to withstand the strains of nor-

mal operation will often not be punctured, even though it may be subjected to double normal voltage by these static strains; on the other hand, air distances subjected to such strains, including "surface distances" so called, can readily break down instantly from static strains, and, indeed, especially surface distances, may be and are more sensitive to static than other strains. It is necessary, therefore, in planning a high tension system to provide a very wide margin for air spaces at all exposed points and long surface distances between live parts to insure safety from static disturbances. On the other hand, very little increase is required in the actual thickness of solid material over that required to stand normal strains. This conclusion must be taken in conjunction with the discussion below under the head of "Local Concentration of Potential."

Most engineers do not appreciate the importance of this caution. Once a plant is installed with air distances too small, these will be an occasional cause of shut-down and loss until remedied.

In planning insulation distances it must be remembered that the striking distance of high voltages from 20,000 to 100,000 volts increases much more rapidly than the voltage, and that consequently for the higher voltages much more than proportionate spaces must be allowed. This phenomenon is one of the reasons why insulators for very high voltages have to be excessively large in comparison with insulators for perhaps 10,000 to 15,000 volts. The disadvantage to the insulator manufacture is further increased by the fact that the weight and material of the insulator increase somewhere nearly according to the cube of the linear dimensions, while the insulation strength increases more slowly than the first power.

It is of course customary and desirable to prevent as far as possible an abnormal rise of temperature above the earth by means of suitable lightning arresters. However, it is evident that lightning arresters cannot be placed at all points of the system where a rise of potential may be produced by static disturbances. They should usually be placed, however, where important apparatus is to be protected. At

other points ample insulation distances, as outlined in the paragraph above, must be provided.

Local Concentration of Potential.—More serious than the momentary rise of potential just discussed is the strain produced upon coils connected to the high-tension circuits by static waves. It is well known that very abrupt waves or discharges pass only with great difficulty and slowly through choke coils, and that a static discharge will jump through considerable insulation rather than follow around the turns of a powerful choke coil. The high tension coils of transformers form extremely powerful choke coils and are subjected to very severe strains between the turns or layers when static waves reach their terminals. There is another way of looking at this phenomenon:

When a static wave reaches a transformer coil, on account of the enormously increased inductance and capacity of this winding over the line, its speed is greatly reduced. This means that when the beginning of the wave has reached a point, perhaps one-third of the way to the end of the coil, that the crest of the wave has reached the end of the terminal of the coil. Therefore, a difference of potential exists between the terminal and a point one-third the way through equal to the full potential of the static wave. This wave may be even greater than full-line potential, and the high-tension coil referred to may be one of a number which normally divide the full-line potential between them. Consequently the momentary strains upon the outer parts of the coil may be a great many times the normal voltage impressed by the generator. If the insulation between turns of the coil be not extremely good a spark will pass between them. This spark tends directly only to pass the energy of the static wave, which is very small in actual amount and almost harmless. Unfortunately, however, there may exist at this time a voltage between the turns between which the spark passes, maintained by the generator, which, though much smaller than the static voltage, is still able when once the insulation is broken down by the latter, to start and maintain an arc. Although the static spark of itself was nearly harmless, the

arc maintained by the generator, if once started, will very likely destroy the coil. In case, however, that the normal voltage between layers or turns is very small, or in case the static spark occurs at an instant of time when the voltage of the generator is nearly zero, or, perhaps, under other conditions, the generator electromotive force will not be able to start a local arc. Fortunately, this will usually be the case. However, although each static spark which may pass between turns is in itself not particularly harmful, yet if for any reason a large number of such sparks pass in the same spot, a final deterioration of the insulation will result and a short circuit ensue at a later time, which may finally occur apparently without any connection with any static disturbance. As a matter of fact, static disturbances are very difficult to trace out in their effects within transformers.

It is evident that the same strain between turns in a coil will be produced by a negative wave as by a positive—if it be as abrupt. That is, a sudden dropping to zero of the potential of the transformer terminal produces the same strain as suddenly charging it to the same amount.

This local concentration of potential is neither an uncommon nor an uncertain phenomenon. It may be reproduced at any time in a laboratory or factory, or at a powerhouse, by a simple experiment, and undoubtedly occurs in commercial operation of plants. It is necessary only to cause a static disturbance near the terminal of a coil and measure by a spark gap the momentary voltage between the lead and points a portion of the way through the coil. Static waves are of great importance to the operating man, however, only on very high voltages.

It is evident that the condition which causes the local concentration of strain to be extremely severe is the abruptness of the static wave. The more abrupt the wave, the less distance will it have penetrated a transformer coil before the terminal has attained the full potential of the wave. This sort of strain is analogous to the breaking of a plastic body by a very sudden blow.

Protection of Circuits and Apparatus.—Protection of two

types is required: (1) Lightning arresters to protect against abnormal rise of potential above the earth and the low tension circuits; (2) protection against local concentration of potential.

Grounds.—There are a number of ways, theoretically, in which static waves can be destroyed, or rather diffused, and prevented from doing serious injury. (1) The introduction of a choke coil in the line will divide a static wave in two parts, one portion passing on, the other being reflected back; the proportions of these parts for any given wave being determined by the size of the choke coil. If a number of these choke coils were placed at a number of points in the line so that reflection would occur several times, the wave would be distributed in a number of parts, each of which would act alone and be unable to do damage. However, this method is impracticable because each different static wave length would require a different choke coil to divide the static wave properly, and because such choke coils would seriously interfere with the normal operation of the system.

(2) Short branch lines would be excellent, as each would subtract a portion of the energy of the original wave, which would soon be reduced to a harmless magnitude. This method is of doubtful effectiveness, however, since the length of line necessary to actually withdraw energy from the original wave must be greater than the wave length of the static discharge. This length will vary greatly and might be so great as to render the cost of such branch lines prohibitory. Such lines must evidently be taken from some point of the main line, other than a reflecting point, or, as already explained, they will themselves experience an abnormal rise of potential. It is probable that branch lines and changes in the size or number of line wires (which has much the same effect) do help in many instances to reduce the severity of waves, but it is the opinion of the author that it is hardly feasible to devise such an arrangement with reasonable expense which can be relied upon to dissipate waves in all cases.

Both of the above methods fail also in cases where static

waves originate near apparatus and do not pass through any considerable length of line before having an opportunity to do damage.

(3) Lightning Arresters. The only method in practical use at the present time is the employment of lightning arresters which are merely opportunities for the line to discharge to ground when reaching a potential sufficiently high above normal.

They may be made quite satisfactory for accomplishing this purpose at the particular point of the system to which they are connected, provided two secondary effects are neglected. (1) The arcing over the arrester following a discharge, which has been frequently discussed, and (2) the local concentration of potential resulting from the extremely abrupt negative wave caused by the reduction to earth potential of the circuit at the arrester. Various ways are proposed and used for the interruption of the arc in the arrester, all of which hinder the original function of the arrester to some extent; that is, the free discharge of the line. In high tension work the most successful means is series resistance in the discharge path of the arrester. By preventing any considerable flow of current from the generator this series resistance may be made to render almost any lightning arrester non-arcing. Every available means, however, should be used to reduce the amount of series resistance to a minimum, as it may seriously impede the discharge of the line. The use of non-arcing metal and a large number of small gaps in place of one large gap, as is done in nearly all commercial arresters, makes a very considerable gain in this direction. Another means for still further reducing the series resistance will be briefly described under the head of the low equivalent arrester.

The local concentration of potential produced by the lightning arrester discharge is not different from a similar effect due to other causes except that it is perhaps more severe since closer to the apparatus. It needs no separate consideration.

Short Circuits.—The prevention of dangerous local concentration of potential may be accomplished by several

methods. (1) By insulating windings, especially near the terminals, sufficiently heavy to withstand the strains produced by static waves in the particular circuits in which this apparatus is to be used. This method is very satisfactory in its simplicity, and is entirely feasible for moderately high voltages. It is the method usually employed for this purpose.

(2) Windings may be so arranged, for example, by winding one turn per layer, as to very greatly reduce the static potential between layers and also the normal voltage between layers, and thus very much reduce the probability of the formation of a local arc in case of a static spark. This arrangement of windings extends the range of voltage for which insulation can be used commercially sufficient to stand static strains, but is inadequate in the highest voltages for the protection of the insulation between the coils or section of coils which are thus wound.

A more complete method, a method of prevention rather than resistance, which is available for higher voltages than those already mentioned, is the use of the static interrupter, which is substantially a magnified choke coil. Its function is to so delay the static wave in its entry into the transformer coil that a considerable portion of the latter will become charged before the terminal will have reached full potential. Protection by a choke coil will first be discussed.

If a very heavily insulated powerful choke coil be placed in the lead of the transformer, when a static wave approaches electricity will begin to pass in small quantity and will pass in gradually increasing quantity at later instants of time, so that the coil will be, comparatively speaking, gradually brought to full potential; meanwhile the volume of the static wave is being reflected and choked back and perhaps being discharged to the ground if there be a lightning arrester near. It is evident that this choke coil, to be effective, must be so proportioned as to delay the incoming wave enough so that the portion of the winding which has become charged when full potential is reached at the terminal shall be sufficient to withstand the strain of the full voltage of the wave. It is evident that such adjustment

does not depend directly on the freqency or abruptness of the static wave, since both the transformer and the choke coil are similarly affected by the frequency.

But a choke coil sufficiently powerful to accomplish this

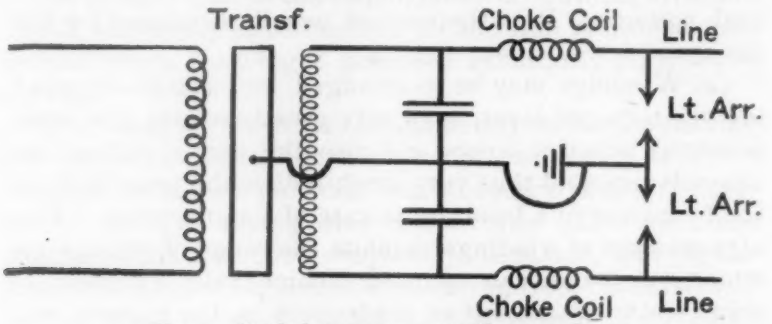

FIG. 3.—Static interrupter protecting transformer.

result satisfactorily is found to be impracticable on very high potential circuits on account of the size, cost and interference with the operation of the system. However, if the arrangement of the static interrupter be used, that is, if a

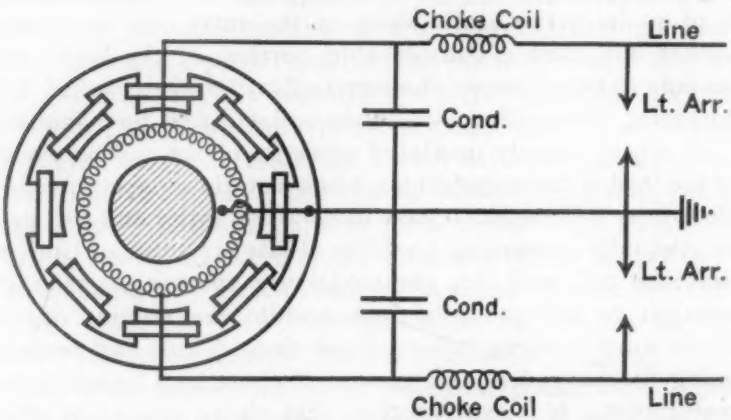

FIG. 4.—Static interrupter protecting high-tension generator.

condenser be connected between line and ground behind the choke coil nearer the apparatus to be protected, this choke coil will absorb a considerable portion of the current actually passed by the choke coil, and the time required to pass

sufficient electricity to charge the terminal will be much increased. With this arrangement a comparatively small choke coil may be used. The condenser has a very small electro-static capacity, and has no appreciable effect upon normal operation, and yet has a very powerful effect on the static wave on account of its extremely high frequency. As in the case of the choke coil, the static interrupter must be roughly proportioned to the transformer winding to be protected. The condenser must also be suitable for the voltage between line and ground.

If static interrupters be placed in each lead of high tension apparatus which may be injured by local concentration of potential, its windings will be amply protected against danger of short circuits from static wave either positive or negative. Such an arrangement is shown diagrammatically in connection with a transformer and a high tension generator in *Figs. 3* and *4*.

A large number of these interrupters have been manufactured and are in actual service.

Static Interrupters and Low Equivalent Lightning Arresters.—A short description of the salient features of some actual lightning arresters and static interrupters designed by the author for the purpose of protecting apparatus from static disturbances will be given.

The low equivalent A.C. lightning arrester consists of a number of $\frac{1}{32}$ inch air gaps between non-arcing metal cylinders in series with non-inductive resistance. A portion of the resistance, called shunt resistance, is shunted by a second set of air

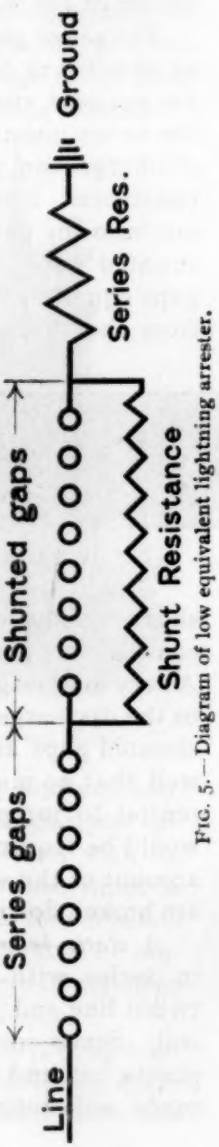

FIG. 5.—Diagram of low equivalent lightning arrester.

gaps called shunted gaps. The object of this arrangement is to reduce the amount of the series resistance through which the discharge must pass to ground. This arrester is diagrammatically illustrated in *Fig. 5*. The apparatus is shown in *Fig. 6*.

The series gaps withhold the line voltage and are chosen so as to break down at something between 50 per cent. and 100 per cent. rise of voltage above the earth. A portion of the series resistance is shunted by gaps so that the static discharge can pass around this portion, thus avoiding its resistance. It evidently is then necessary to suppress the arc from the generator which tends to follow through the shunted gaps. It is found that with a number of shunted gaps equal to the series gaps, the arc will be withdrawn from the shunted gaps by the shunt resistance when the

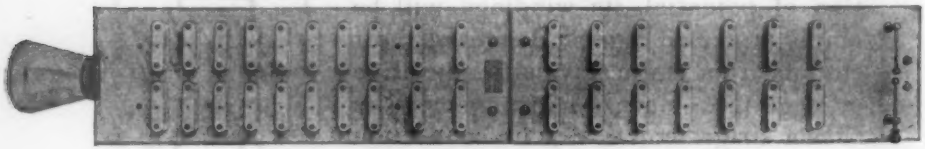

FIG. 6.—Low equivalent A. C. lightning arrester.

shunt resistance does not exceed a proper value, which is a considerable portion of the total resistance in the arrester. A very marked gain in the reduction of the resistance offered to the discharge is therefore made by means of the use of shunted gaps and shunt resistance. It must be noted as well that no more voltage is required to cause a rise of potential to jump over all the gaps series and shunt than would be required to jump the series gaps alone, since on account of the shunt resistance the series and shunted gaps are broken down separately one after the other.

A static interrupter, see *Fig. 7*, consists of a choke coil in series with the line and a condenser connected between line and ground on the apparatus side of the choke coil. Since interrupters are used only on high voltage plants, coil and condenser are placed in oil tanks which are made self-cooling. The coils are extremely heavily insu-

lated. The condensers are built up of specially prepared insulating paper and have rectangular copper plates with rounded edges and corners. There is a considerable amount of heat generated in condensers which is a difficult matter to dissipate on account of the poor heat-conducting quality of the insulating material. These condensers are all provided with ventilating ducts which allow a passage of oil from the bottom upwards at frequent intervals to the interior.

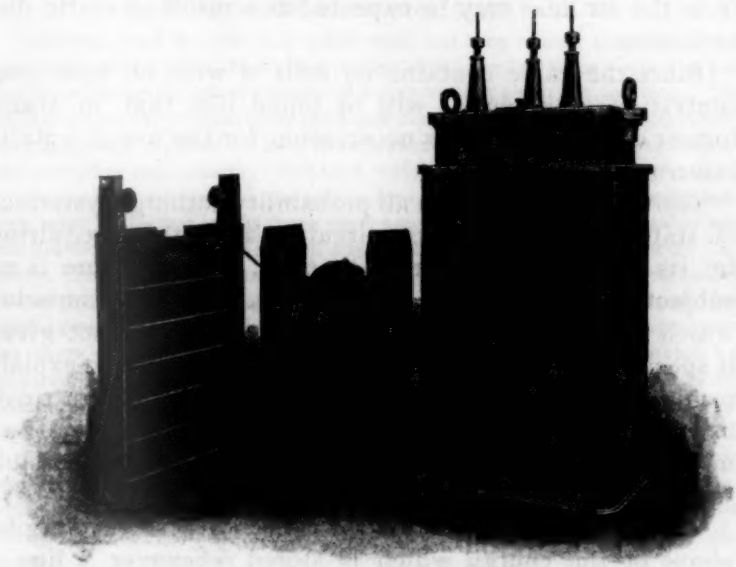

FIG. 7.—Static interrupter, showing coil and condenser out of case.

This condenser loss is quite an interesting phenomenon. Its amount increases as the square of the voltage upon the condenser, roughly, and is very rapidly increased with increase of temperature. The loss increases several times in amount between 50° C. and 100° C. This loss also depends upon the frequency of the circuit and for the kind of material used; for the dielectric in these condensers it increases approximately as the square root of the frequency.

Cables.—The high tension electric cable is in principle no different from the electric air line, but has a different insulating material, paper or rubber in place of air. This has

the double effect of increasing its electrostatic capacity and changing the velocity at which waves progress. The increased electrostatic capacity tends to decrease the speed, but as the inductance of the cable is small this partially compensates for the increased capacity. The differences from the air line are differences in degree only and do not affect the passage of waves, reflection, resonance, etc., as already discussed. Consequently, no phenomena different from the air lines may be expected as a result of static disturbances.

Since the cable contains no coils of wire, no local concentration of potential will be found like that in transformer coils, and there is no occasion for the use of a static interrupter.

Conclusion.—There is in all probability nothing mysterious in static waves in electric circuits and nothing requiring for its explanation any new theories, and yet there is no subject connected with commercial power transmission which is so little understood by those who have not given it special attention, and in which it is so difficult to explain results. The difficulty arises not so much from intrinsic blindness in the subject as from the great difficulty of measuring and tracing these extremely rapid and invisible waves.

In a general way it must be expected that the surging about of the energy which is stored whenever a line is charged will cause increased potential at certain points. This should be provided for by placing suitable lightning arresters at all points where important and vulnerable apparatus is located. There will also be local concentration of potential in windings connected to the circuits as the result of all static disturbances. Such transformer or other coils should always be either sufficiently insulated or protected by choke coils or static interrupters or by some other suitable method.

The apparatus shown in connection with this lecture shows one arrangement designed by the author for protection of circuits and apparatus from static disturbances.

It is highly desirable that this subject should receive as

much discussion as possible, and that further experiments should be tried and observations made by engineers and superintendents of power plants, and that all work together to determine the best methods of protection against this troublesome and elusive source of interruption of service and loss of apparatus.

PRODUCTION OF LEAD AND LEAD OXIDES.

It is important to note that while there has been a large increase in the consumption of lead in the United States during the last three years, the production of domestic mines remains at a standstill at about 280,000 tons. The additional quantity required by the home demand has not been, as might have been supposed, supplied by lead from Mexico and other foreign ores smelted and refined in this country. This lead, which is refined here in bond, has been almost entirely re-exported, the entries for consumption at home having been very small. The fact is that three years ago production had considerably outrun the demand then current, and the stocks carried by producers were very heavy. The increased demand has enabled producers to work off these stocks, and to reduce their holdings to normal amount, so that at the present time they are really low. The increase in consumption during the last three years has come partly from the great activity in building operations, which has required the use of large quantities of lead, partly from the increase in the demand for sheet lead for insulating cables and similar electric work, and partly from the demand for lead for use in various alloys.

The production of red lead, litharge and orange mineral has shown no very important increase during the last three years; nor has the production of white lead, although there was a considerable increase in the make in 1902. White lead has certainly suffered from the competition of other white pigments. If the improved Dutch processes that are now attracting so much attention, result in such a decrease in the cost of manufacture as is anticipated, white lead may be able to regain its lost ground.—*Eng. and Mining Journal.*

PRIZES OF THE SOCIÉTÉ INDUSTRIELLE DE MULHOUSE.

We have received a copy of the program of prizes to be awarded in 1904 by the Société Industrielle de Mulhouse. There are no fewer than fifty six competitions concerned with chemical technology, more than twenty dealing with the mechanical arts, and twelve with natural history and agriculture. Several prizes are offered with the object of improving and stimulating local industries. The program also contains full particulars of several large prizes of 5,000 francs, which are awarded for scientific work at intervals of in some cases ten, and in others five years.

The present publication takes the place of all previous issues, and copies of the program, in which certain changes have been made, can be obtained on application to the secretary of the society.

RADIO-ACTIVE ELEMENTS.

The opening address of Prof. W. N. Hardley, president of the Section of Chemistry, at the last meeting of the British Association for the Advancement of Science, contains the following interesting reference to the so-called radio-active elements:

"From the study of rays of measurable wave-lengths we have lately sailed under the guidance of M. Henri Becquerel into another region where it is doubtful whether all the rays conform to the undulatory theory. In fact some of the rays are believed to be charged particles of matter, charged, that is to say, with electricity. Beyond doubt they are possessed of very extraordinary properties, inasmuch as they are able to penetrate the clothing, celluloid, gutta percha, glass and various metals. They are, moreover, endowed with a no less remarkable physiological action, producing blisters and ulcerations in the flesh which are difficult to heal. It is an established fact that such effects have been caused by only a few centigrams of a radium compound contained in a glass tube enclosed in a thin metallic box carried in the pocket.

"From this we can quite understand that there is no exaggeration in the statement attributed to the discoverer, Professor Curie, by Mr. W. J. Hammer, of the American Institute of Electrical Engineers, that he would not care to trust himself in a room with a kilogram of pure radium, because it would doubtless destroy his eyesight, burn all the skin off his body, and probably kill him."

TECHNICAL NOTES.

Although the United States consumed last year approximately 520,537 long tons sulphur, exclusive of the sulphur recovered from the fumes from roasting blende, its own supply was little more than one-quarter of this quantity, chiefly in iron pyrites. The bulk of the demand is still satisfied by imports of brimstone from Sicily, and of iron and copper pyrites from Spain and other countries.——Metallic calcium is likely to become an important industrial product, if the methods of manufacture can be improved so as to reduce the cost. It is of value as a reducing agent and as a purifier of iron. The present cost of manufacture by electrolysis is about 45 cents per pound.——The steam turbine, which, many engineers think, promises to revolutionize the generation of power from coal, is, on account of its high speed, especially suited to the driving of electrical dynamos. The General Electric Company was quick to perceive this, in taking up the manufacture of the Curtis turbine engine, which it is now exploiting on a large scale.——Platinum is obtained in ordinary placer mining, in the Urals, California and elsewhere, but its occurrence in place in the rock is very rare and difficult of determination. It has been found in the peridotite, serpentine and olivine rocks of the Urals, but so finely disseminated that careful search has but rarely proved successful.——As greater depth is attained in Dolcoath mine, Cornwall, the finer becomes the tin; that is to say, the particles of cassiterite become more minute. This necessitates stamping to a greater degree, with additional care in treatment of slimes. With an ore containing only 1·5 to 1·75 per cent., the treatment is a difficult matter.—*Engineering and Mining Journal.*

PHYSICAL SECTION.

Stated Meeting, held April 23, 1902.

Electric Convection—A Historical Summary with a Bibliography.

By J. Frank Meyer.

If the theory of the electro-magnetic field as advanced by Maxwell in his celebrated treatise is true, the four following deductions from the theory should be true, and it should be possible to verify them experimentally:

(1) An electric charge in motion should produce a magnetic field.

(2) A varying magnetic field should produce an electric field.

(3) A magnetic pole in motion should produce an electric field.

(4) A varying electric field should produce a magnetic field.

These four points all seem to lack conclusive experimental verification, and so far only (1) and (2) have been attempted. However, a verification of any one of the four is practically proof of all the others.

It is said that as early as 1868 or 1869, the idea occurred to Professor Rowland that an electric charge in motion should produce a magnetic field. When Maxwell published his treatise in 1873 he suggests an experiment, but remarks that so far the experiment had not been tried.

If we have two parallel plane surfaces, electrified to surface densities σ and σ^1, then the mutual repulsion per square centimeter is $2\pi\sigma\sigma^1$. If we now assume that a charge in motion is equivalent to a current, we may move the planes with a velocity v in their own planes, and this will cause an attraction between the planes.

If u and u^1 are the surface densities of current, it may be shown that the attraction is $2\pi u u^1$ per unit area, u, and u^1 being measured in electro-magnetic units.

If the surface density in electrostatic measure is σv and $\sigma^1 v$, and n the number of electrostatic units in one electromagnetic unit, we have:

$$u = \frac{\sigma v}{n}; \quad u^1 = \frac{\sigma^1 v}{n}$$

Therefore:

$$2 \pi \sigma \sigma^1 = 2 \pi \sigma \sigma^1 \frac{v^2}{n^2}$$

and, finally,

$$v = n.$$

In other words, the ratio of the units is a velocity, and though it is not possible to move a charged plane with a velocity $v = 3 \times 10^{10}$ centimeters per second, it is possible to move the charge rapidly enough, so that if a magnetic effect does exist it can be measured.

Rowland* attacked the problem in this way: A hard-rubber disk, 21 centimeters in diameter, was gilded on both sides and mounted on a vertical axis. The disk thus rotated in a horizontal plane. Above and below the disk was a glass plate, also gilded. Above the upper of these two condenser plates was hung an astatic needle. The gilded disk was charged by bringing within $\frac{1}{8}$ millimeter of its edge a wire point connected to a battery of Leyden jars. When the disk was rotated about sixty-one times per second, and the electrification on the disk changed, a deflection of from 6 to 8 millimeters was observed on the scale.

To guard against conduction currents in the gilding on the disk, scratches were made through it. But the same deflections were obtained. The calculated and observed deflections agreed very well, but as the needle was always unsteady, the measurements obtained were not as accurate as might have been desired. The experiment has, however, been very generally accepted, and its results have been incorporated into the text-books, while the effect is known as the "Rowland effect."

In 1884 Lecher repeated the experiment with slight modifications, but with negative results. It has been suggested that his apparatus was not sensitive enough to detect the

* *Pogg. Ann.*, clviii, p. 487.

effect. This, however, hardly seems possible, for he used an astatic needle in the axis of a vertical disk, 200 cm. in diameter, charged to 5,000 volts and rotated with a speed of 200 revolutions per second. The charge was measured by an absolute electrometer.

Röntgen in 1885 used an apparatus similar to Rowland's in an attempt to observe displacement currents. He got deflections of his needle slightly larger than those obtained by Rowland, when the ungilded ebonite disk was charged by means of a brush discharge from points. Again in 1888 Röntgen used the same apparatus in order to investigate the action of a dielectric revolving in a homogeneous electrostatic field. The dielectric was rotated around a vertical axis between oppositely charged condenser plates. Precautions were taken to prevent the rotating disk from getting a real charge, and deflections of a few millimeters were obtained when the electrification on the condenser plates was reversed.

Professor Rowland and Mr. Hutchinson again took up the question in 1889.* They used two disks facing each other, and gilded on their inner faces. Each disk ran in a guard ring, between two condenser plates, on horizontal axes. The condenser plates were charged to about 5,000 volts, while the disks were kept earthed by brushes bearing on buttons sunk into the periphery of the disks. With speeds of about 120 to 125 revolutions per second, deflections of from 5 to 8 millimeters were observed. These deflections reversed in direction as the electrification was reversed. From this experiment a value of v was calculated, giving as a mean $v = 3{\cdot}19 \times 10^{10}$, the largest variations being between $3{\cdot}74 \times 10^{10}$ and $2{\cdot}26 \times 10^{10}$.

In the same year Professor Himstedt† used a very similar apparatus. He used two ground glass plates with a strip along the edge of each made conducting by rubbing graphite on the surface. His needle system was so placed that the

* *Phil. Mag.*, 5, xxvii, p. 445 (1889). Rowland's "Physical Papers," pp. 128, 138.

† *Wied. Ann.*, 38, p. 560 (1889).

upper and lower needles about coincided with the conducting strips. When the disks were charged, the condenser plates between which each disk ran being earthed, a deflection of the needle system was readily obtained. The deflection was in the direction to be expected, reversed in direction when the charge was reversed, and from 400 to 4,000 volts was proportional to the charge. Charges as high as 14,000 volts were used, but the proportionality did not hold beyond about 4,000 volts.

About this time Lippmann* called attention to the reciprocal of the Rowland effect, and in 1897 Crémieu† took up this reverse problem: to find the mechanical force exerted on a charged body by a rapidly changing magnetic field. This force is a very small quantity. Crémieu attempted to detect it by rotating an aluminum disk between the poles of an electromagnet. The calculated effect was about 100 millimeters, but no effect could be observed. It should be noted, however, that in 1889 Professor Lodge did observe this effect, though not as satisfactorily as he desired.

The negative results in this experiment led Crémieu to investigate the Rowland effect, and after several years of work he concluded that an electric charge in motion does not produce a magnetic field.

Crémieu's method is new and ingenious, for instead of a magnetometer needle he uses a coil of wire and a galvanometer, thus noting the current induced in the coil by the changing magnetic field, if such a field does actually exist.

A solid aluminum disk 37 centimeters in diameter was mounted on a hard-rubber hub on a horizontal axis. Concentric with and around this disk was a coil of 13,000 turns of copper wire 0·15 millimeters in diameter. The coil was entirely enclosed in a hoop of brass and in series with it was a sensitive galvanometer. The diameter of the coil was 44 centimeters.

The disk was arranged to rotate between two thick iron plates 8 millimeters apart. A brass ring on the hub was

* *Comptes Rendus*, 89, p. 151 (1889).

† *Comptes Rendus*, 130, p. 1544 (1900).

put into connection with one terminal of a battery of Leyden jars, the other terminal being earthed. In this manner the disk was charged to about 5,000 volts.

Now on the assumption that a moving charge produces a magnetic field, a current should be induced in the coil, if the charged disk is rotated and discharged and again charged in succession. A commutating device was used in order to charge and discharge the disk, and at the same time commutate the current flowing through the galvanometer. No deflection whatever could be observed, though the theory predicted a deflection of about 20 millimeters.

Crémieu varied the experiment in several ways:

(1) The aluminum disk charged to 5,000 volts was rotated between iron plates. It was found, however, that sparks passed from the disk to the plates, the distance between the plates being only 8 millimeters. To prevent this, the iron plates were covered with lacquered glass plates 2 millimeters thick.

It was suggested by Pellat that even then the charge brushed across the space to the glass, leaving the disk uncharged. Crémieu tested this when the disk was at rest, and found that the charge did not pass over the gap. But it is possible that when the disk was rotating in the gap, only 1·75 millimeters wide with a speed of 110 revolutions per second, the charge did brush across. Only negative results were obtained from this experiment.

(2) A second experiment with the rotating disk covered with caoutchouc, the condenser plates being bare, also gave negative results.

(3) An ebonite disk gilded in sectors gave similar negative results.

(4) By rotating the disk in a brass drum with sides parallel to the disk, the sides being covered with mica on the inside and then gilded, no results were obtained. A needle was used to detect the effect in this form of the experiment. But when the brass ends were removed, leaving only the mica end, a slight deflection was obtained.

Mr. Wilson, of the Cavendish Laboratory, has pointed out that currents would be induced in the brass ends, with

effects exactly opposite to those due to the disk, and that the experiment therefore confirms the theory.

M. Crémieu concludes that whenever the magnetic system is protected by a good conducting screen, it is not possible to obtain a deflection of the needle due to the magnetic field produced by the moving charge, and if any deflections do occur, they are due wholly to electrostatic effects. Therefore, as a final deduction, "open circuits" must exist, and Crémieu* proceeded to show their existences in the following manner:

An ebonite disk 37 centimeters in diameter and 2·5 millimeters thick, was gilded on one side in twenty-five sectors, a space of 1 centimeter being left ungilded between the sectors. This disk was mounted so as to rotate in a horizontal plane between two ebonite plates that served as condensers.

The plate facing the side of the disk not gilded was gilded over a sector twice as wide as one of the sectors on the disk. On the other condenser plate, exactly opposite the large sector, was placed a brush that made contact with the sectors on the rotating disk, as each one passed under the large sector on the condenser plate. This brush was connected to another 60° ahead of it, through a galvanometer.

Now if the fixed sector is charged from some source of electricity when a sector on the disk comes under it, the revolving sector acquires a charge by induction. This charge is then carried forward to the second brush where it is discharged. There is then a circuit partly convection and partly conduction. To find if the electricity in the convection part of the circuit produces a magnetic effect, a needle was hung between the brushes. The sector was charged to about 100 to 130 C.G.S. units, being distant from the rotating sectors 0·5 centimeter.

When the disk was rotated, a current of from 10^{-4} to 2×10^{-4} amperes flowed through the galvonometer, while there was no effect on the needle system. But a conduction

* *Comptes Rendus*, 132, p. 1108.

current of same value deflected this needle 15 millimeters on a scale 4 meters distant.

Crémieu concludes, therefore, that the electricity carried by the sectors has no magnetic effect, that is, that an open circuit exists.

In 1901 Pender* published the results of an investigation carried out under the direction of Professor Rowland, in which Rowland's previous results were confirmed in all particulars, thus contradicting the work of Crémieu.

Pender used two micanite disks, 0·356 centimeter thick, 30 centimeters in diameter, gilded on both sides and mounted on horizontal axes. Opposite each face of each disk was a condenser plate of hard rubber, covered with tin foil. These plates were about 1 centimeter apart, and were earthed. The disks were charged by means of brushes on brass rings from a Voss machine and six Leyden jars. Between the jars and disks was a reverser so arranged that the charge could be changed twelve to twenty-five times per second. The disks were rotated from 75 to 110 times per second.

Between the two inner condenser plates was a coil of 1,295 turns of No. 21 copper wire. This coil was 30 centimeters in diameter and enclosed in a metal case, which was connected to earth. The coil was connected through a commutator on the same shaft as the reverser to a sensitive galvanometer.

It was possible to rotate the disks in the same direction with similar charges, or in opposite directions with dissimilar charges. The latter method was used most frequently.

The direction of the galvanometer defection could be compared with that due to a current flowing in a test coil on the disk. This deflection was always in accord with Ampère's rule; the motion of a positive charge produces the same effect as that of a conduction current flowing in the direction of motion of the charge.

From 17 sets of observations, consisting of 18 determinations each, the mean value of v was found to be:

$$v = 3{\cdot}05 \times 10^{10}.$$

**Physical Review*, 13, p. 203, 1901.

The greatest variations obtained were:

$$v = 2{\cdot}75 \times 10^{10}$$
$$v = 3{\cdot}24 \times 10^{10}.$$

These results were further confirmed by rotating the disks, when similarly charged, in opposite directions when no deflections of the galvanometer occurred. Afterwards, scratches were made through the gilding on the disks, and the mean of readings gave for v the value $v = 1{\cdot}96 \times 10^{10}$.

Pender has repeated the experiment,* making greater variations in the speed of the disks and the charges were more varied, with confirmatory results.

Two other experiments have confirmed the effect. Adams† rotated copper spheres fastened to the ends of spokes of two wheels. The wheels were rotated with opposite charges of about 18,000 volts, and the effect was readily detected and measured.

Eichenwald‡ confirmed the effect by rotating a micanite disk between zinc condenser plates, using a needle system protected in a box of electrolytic copper.

The edge of the disk was covered with tin foil and the needle was placed over the edge. The calculated capacity of the condenser was 5×10^{-11} farads, and the convection current was $4{\cdot}5 \times 10^{-6}$ amperes. When a conduction current of $4{\cdot}5 \times 10^{-6}$ amperes was sent through the coil, the same deflection of the needle was obtained.

Dr. Pender has recently taken his apparatus to Paris, and it is hoped the reason for the contradiction between his work and that of Crémieu will be explained.

Supplementary Note.—Messrs. Crémieu and Pender have recently published the results of their joint work§ carried out at the Physical Laboratory of the Sorbonne and arrive at the following conclusions:

(1) A charged continuous metallic disk turning in its own plane opposite fixed condensing-plates carries its charge with itself.

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* Pender: *Physical Review*, 15, p. 291.

† Adams: *Phil. Mag.*, **6**, 2, p. 285, 1901.

‡ Eichenwald: *Phys. Zeit.*, 2, p. 705.

§ Crémieu and Pender: *Phil. Mag.*, **6**, 6, p. 442, 1903.

(2) The *entrainement* of this charge produces a magnetic field in the direction demanded by the assumption of a magnetic effect due to electric convection, and in accord with the calculated value to 10 per cent.

(3) Charged sectors moving in their own plane, without the presence of any condensing-plates, produce a magnetic effect in the direction and of the proper size demanded by this same assumption.

The authors of this joint paper say further: "It is not for us to say whether these effects are really due to electric convection in the sense in which Faraday and Maxwell understood this expression, nor to decide whether they are in accord with the fundamental hypotheses of the accepted theories."

RANDAL MORGAN LABORATORY OF PHYSICS,
UNIVERSITY OF PENNSYLVANIA.

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BERLIN-ZOSSEN HIGH-SPEED ELECTRIC RAILWAY.

Continuing the experiments on the Berlin-Zossen military road, the German electrical engineers engaged on the work have now succeeded in pushing the speed of the car above 125 miles an hour. A cable dispatch from Berlin of October 6th, says:

"An electric car on the Marienfelde-Zossen experimental line reached a speed of 125⅘ miles an hour to-day, or a kilometer more than the highest previous record. The machinery and roadbed were unimpaired. The engineers are determined to try for still higher speeds and venture the opinion that they will be able to attain the rate of 140 miles per hour. The current was between 13,000 and 14,000 volts, capable of driving the car at the rate of over 200 miles. This power is reduced by transformers to about 450 volts. The car used to-day had four motors, having together about 1,100 horse-power. It was the car used in the previous tests this year, and is constructed on the Siemens-Halske system. Another car of somewhat different equipment as to motors and transformers has been built for additional high-speed tests.

"The lives of all on board the experimental car were heavily insured. A large party of engineers, military men and civilians gathered at Dallwitz, where the highest points of speed are reached in these experiments. A French observer remarked that the new sensation of the power of velocity inspired by the car's flight was worth traveling from Paris to see. There were twelve to fourteen persons on board the car, all technical men. They affirm that the motion of the car was no greater than that of an ordinary express train. A curious phenomenon accompanying the car is the continuous sparking of electricity from the six trolley arms.

"While the engineers do not believe a speed of 125 miles is practicable at present on the State railroads they are prepared to recommend a speed of 93 miles an hour between Berlin and Hamburg."

Correspondence.

SOME IMPORTANT POLAR NAVIGATIONS TO HIGH LATITUDES. (Faustini-Balch.)

To the Secretary of the Franklin Institute:

SIR:—Among other interesting articles, the June number of the *Journal of the Franklin Institute* contained one which was of special interest to me as a Dutchman (or let me rather say as one of Netherlandish origin, as I am a native of these colonies); it interested me especially as it contained much information about the bold expeditions of our forefathers; it was Dr. Arnoldo Faustini's Polar Navigations, translated by Edwin Swift Balch. But in one place I was sorry to note that it was sadly in error, that is to say, in the citation of page 421 of a sentence of Willem van Muyden's petition to the States General, and in the accompanying translation. Allow me to correct both. A somewhat literal translation should sound as follows:

"With a quantity of ships where never Christian man about had been, yes that they had passed 83 degrees where their ships had found a vast sea, without ice, flat pasture land with herbivorous fauna."

(Especially the last or final passus is quite different from the author's translation.)

The citation itself should read as follows:

"Met eene quantiteit schepen alwaar nooit christen mensch omtrent (instead of 'outrent') hadt geweest (instead of 'gewest') ja dat zy hadden gepasseerd 83 graden, alwaar haare schepen gevonden (instead of 'geronden') hadden eene ruyme (instead of 'ruyne') zee, zonder ys, vlak weidland met graseetende gedierte."

I hope this correction will prove to you the interest I feel for the Institute bearing the name of one as great as a patriot, as a politician and as a scientist, one of the most sympathetic of a broad host of sympathetic founders of a great republic.

I beg to add that John Lothrop Motley's "Rise of the

Dutch Republic" and his "History of the United Netherlands" contains many particulars about these early Arctic expeditions. In language as vigorous as it is fascinating, he describes the efforts of Barends, Heemskerk, and others to force their way through the polar ice.

I hope that you will be aware by this that we, descendants of the old "geuzen" ("Ce ne sont que des gueux," Berlaymont), do not lack in gratitude to so noble a representative of Franklin's great republic (I hope it will never become a "greater republic") as Motley, equally great as a politician, as a historian, jurist, poet, writer and patriot. Peace be with him!

Wishing you prosperity, material as well as moral and intellectual, with your admirable republic, I remain,

Respectfully yours,

H. VAN MEERTEN.

BUITENZORG, JAVA, July 11, 1903.

To the Secretary:

Heer van Meerten's letter is so flattering to Americans that it seems interesting to present it to the readers of the *Journal* as an expression of Dutch colonial opinion. Of the phrase to which he calls attention, I should like to say that I have not seen the Dutch original, but that I copied it literally from Dr. Faustini's paper, in which it reads as follows: "Si sono visitate, esse scrivevano, con una quantità di vascelli, le regioni estreme del Nord, ove mai nessun cristiano prima di noi vi fu, in paraggi molto al di là dell' 83° di latitudine nord, ivi trovandovi un *mare aperto*, senza ghiaccio e terre da pastorizia. '(Met eene quantiteit schepen alwaar nooit christen mensch outrent hadt gewest; ja dat zy hadden gepasseerd 83 graden alwaar haare schepen geronden hadden eene ruyne zee, zonder ys, vlak weidland met graseetende gedierte.)'"

E. S. BALCH.

PHILADELPHIA, November 1, 1903.

Notes and Comments.

THE ELIZABETH THOMPSON FUND.

The fund established by Mrs. Elizabeth Thompson, of Stamford, Conn., "for the advancement and prosecution of scientific research in its broadest sense," now amounts to $26,000. As accumulated income will be available in January next, the trustees desire to receive applications for appropriations in aid of scientific work. Preference will be given to those investigations which cannot otherwise be provided for, which have for their object the advancement of human knowledge or the benefit of mankind in general, rather than to researches directed to the solution of questions of merely local importance. Further particulars can be obtained from the secretary of the Board of Trustees, Dr. C. S. Minot, Harvard Medical School, Boston, Mass., U. S. A. It is intended to make new grants in January, 1904. Decided preference will be given to applications for small amounts, and grants exceeding $300 will be made only in very exceptional circumstances. The following lists of grants for 1902 has not previously been recorded: $125 to Dr. F. T. Lewis, Cambridge, Mass., for investigation of the development of the vena cava inferior; $150 to Prof. Henry E. Crampton, New York, for experiments on variation and selection in Lepidoptera; $100 to Prof. Frank W. Bancroft, Berkeley, Cal., for experiments on the inheritance of acquired characters; $250 to Prof. John Weinzirl, Albuquerque, N. M., for investigation of the relations of climate to the cure of tuberculosis; $300 to Prof. H. S. Grindley, Urbana, Ill., for the investigation of the proteids of flesh; $300 to Dr. Herbert H. Field, Zürich, Switzerland, to aid the work of the Concilium Bibliographicum (an additional grant of $300 was made June, 1903); $250 to Dr. T. A. Jaggar, Cambridge, Mass., for experiments in dynamical geology; $50 to Prof. E. O. Jordan, Chicago, Ill., for the study of the bionomics of Anopheles; $300 to Dr. E. Anding, Munich, Bavaria, to assist the publication of his work, "Ueber die Bewegung der Sonne durch den Weltraum;" $300 to Prof. W. P. Bradley, Middletown, Conn., for investigations on matter in the critical state; $300 to Prof. Hugo Kronecker, Bern, Switzerland, for assistance in preparing his physiological researches for publication; $300 to Prof. W. Valentiner, Heidelberg, Germany, for observations on variable stars.

LORD KELVIN ON RADIUM.

A special dispatch from London of September 12th to a New York daily newspaper says: "What Prof. C. V. Boys termed 'the miracle of radium' has naturally received much attention in scientific circles. At the meeting of the science branch of the British Association Lord Kelvin, in a paper which he read, made an interesting suggestion in connection with its perpetual emission of heat at, according to M. Curie's calculation, a rate of about 90 C. calories per gram per hour. He said that if the emission of heat at this rate went on for 10,000 hours, there would be as much heat as would raise the temperature of 900,000 grams of water 1° C. It seemed utterly impossible to

Lord Kelvin that this would come from the store of energy lost out of a gram of radium in 10,000 hours. It seemed, therefore, absolutely certain that the energy must somehow be supplied from without. He suggested that ethereal waves might in some way supply energy to radium, while it was emitting heat to matter around it. Lord Kelvin illustrated his theory by the following comparison: Suppose a piece of white and a piece of black cloth, hermetically sealed in similar glass cases, were submerged in similar glass vessels of water and exposed to the sun. The water in the vessel containing the black cloth would be kept very sensibly warmer than that containing the white cloth. Here the thermal energy was communicated to the black cloth by waves of sunlight, and was given out as thermometric heat to the water in the glass around it. Thus through the water there was actually an energy traveling inward in virtue of the waves of light and outward through the same space in virtue of thermal conduction. Lord Kelvin suggested that experiments be made comparing the heat emission from radium wholly surrounded with thick lead with that found in the surroundings heretofore used."

AN ARTIFICIAL NIAGARA AT ST. LOUIS.

An immense artificial cascade has been determined upon by the authorities of the St. Louis Universal Exposition as the center piece of the semi-circular lay-out of the principal buildings. The cascade itself will be divided into three parts—a large middle cascade, with a smaller one at each side, the water flowing directly into the head of the Grand Basin. In all, about 90,000 gallons of water per minute will be supplied at a head of 159 feet, forming the greatest artificial water effect ever attempted.

The water will be taken from the Grand Basin itself, and will be raised to the top of the cascade by a pumping station located under Festival Hall. The pumping machinery will consist of three 36-inch single-stage turbine centrifugal pumps, purchased from Henry R. Worthington, of New York City, each driven by a 2,000 horse-power Westinghouse alternating current motor. The total horse-power utilized will thus be 6,000, making this the largest electric pumping station in the world. The pumps and other pieces of machinery for this plant are now being installed at St. Louis.—*Iron Age.*

DOUBLE CARBIDE OF CHROMIUM AND TUNGSTEN.

Moissan and Kouznetzsw. The authors have obtained this new double carbide by heating in the electric furnace, in the carbon crucible, a mixture of 100 grams sesquioxide of chromium, 45 grams of tungstic acid and 30 grams of petroleum coke or sugar carbon. The current must not be of too great intensity, 400 amperes at 75 volts for five minutes being sufficient. Another method of obtaining the double-carbide consists in fusing in the electric furnace a mixture of metallic chromium, tungsten and a small quantity of sugar carbon in the presence of a large excess of copper, always avoiding as much as possible the carbon vapor of the arc. This mass is melted rapidly in a carbon crucible and the copper is maintained in ebullition for one or two minutes. After pulverizing and treating the regulus thus obtained with various solvents, smaller crystalline clusters of the double-carbide are obtained.—*L'Eclairage Elec.*, August 22d.

Book Notices.

Whittaker's Electrical Engineers' Pocket-Book. Edited by Kenelm Edgcumbe, A. M. Inst. C. E., etc. With 149 illustrations. (12mo, pp. vi + 456.) London and New York: Whittaker & Co. 1903. (Price, 3s. 6d.)

This pocket-book appears well arranged for the use of professional and practical electricians. A concise synopsis is given of subjects treated, bringing each up to date. The work contains the usual collection of useful formulas, rules, tables, and statistical data that are indispensable for reference. Special features that have been incorporated are sections on "Estimating for Electrical Machinery" and "Legal Information." These are written from the English viewpoint, but will doubtless prove useful to some American readers.

W.

The Mineral Industry: its statistics, technology and trade in the United States and other countries to the end of 1902. Edited by Joseph Struthers, Ph.D. Volume xi, supplementing volumes i–x. (4to, pp. xxx + 891.) New York and London: *The Engineering and Mining Journal.* 1903. (Price, $5.)

The eleventh volume of this important encyclopedia of the mineral and metal industries which has just appeared, is issued in the same form as the preceding ten volumes, to which it may be regarded as a supplement. The general method of treatment followed in the preceding volumes is retained. Under some fifty general heads, the statistics, technology and trade conditions of all the commercially useful mineral products and metals are dealt with by experts of acknowledged standing in their respective branches, the whole constituting an admirable résumé of the progress and present condition of these important industries.

"The Mineral Industry" has become an indispensable reference work to all who have to do professionally or commercially with the industries to which it relates.

W.

Notes on Electric Railway Economics and Preliminary Engineering. By W. C. Gotshall. vi + 252 pages. Illustrated. New York, 1903. Published by the McGraw Publishing Company. (Price, $2.)

This book is based upon a series of lectures delivered at Lehigh University last spring, the subject of which dealt with the economics of the preliminary determinations and of the construction and operation of high-speed interurban electric railroads.

The book treats exclusively of high-speed interurban railways. Taking up the project from the preliminary office investigation of the probable earnings and expenses it carries it through the course of track location and construction until it is ready for operation.

Part of the book is devoted to a statement of the principles which should be followed in locating a proposed route so as to derive the maximum benefit from the territory to be served.

One of the most valuable parts of the book is Chapter VI, relating to the detail of the computation and determination of the probable passenger and freight gross earnings.

The detail costs of operation and their computation for different schedules are clearly discussed in Chapter VII. The author has placed at hand a method of accurately determining the costs of operation for almost any proposed system, and points out the danger of using the percentage of gross receipts methods now so commonly employed.

In Chapter X there is an excellent discussion of third rail vs. trolley systems, showing the applications and limitations of each.

The data relating to the determination of the probable cost of construction and of the mooted question of train resistance are very complete. Tables and diagrams are also given showing the relation between the energy consumed for different schedules and different distances between stops. The relatively great cost of high speeds is strikingly shown.

The best manner of keeping, systematizing and showing relative construction and operating data and records is also discussed.

The eighteenth chapter sets forth the controlling considerations governing the kind and character and consequent permissible cost of a proposed installation. The principles laid down are illustrated by an assumed case representing actual conditions.

The book concludes with a set of complete specifications for the construction of a moderate sized high-speed interurban electric railway operating over its own right of way.

With a few exceptions all of the full-size original drawings and diagrams which were used in the lectures have been reduced and reproduced for this volume, and appear at their proper places in the text.

Mr. Gotshall's book should be bound to be valuable alike to the practicing engineer and expert, and to the railroad manager, financier and investor.

W.

Cyanid-Prozesse zur Goldgewinnung. Von Manuel von Uslar unter Mitwirkung von Dr. Georg Erlwein. Mit 30 Figuren und 13 Tabellen im Text und 3 Tafeln. 8vo, pp. vi + 93. Halle a. S.: Wilhelm Knapp. 1903. (Preis, M. 4.)

This work constitutes volume vii of the series of Monographs on Applied Electrochemistry which is being issued from the press of this publisher. The volumes which have thus far appeared have been of a high order of excellence, and the present one is in no respect inferior to its predecessors. It treats of the subject generally in a brief introduction, then proceeds to a description of the McArthur-Forrest & Siemens-Halske processes, giving examples of the application of the method taken from various works. Then follows a chapter on the chemistry of the processes; and in conclusion a brief description of the various modifications of the cyanide process. Among the illustrations are plans and elevations of working plants.

W.

Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, November 18, 1903.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, November 18, 1903.

Vice-President JAMES M. DODGE in the chair.

Present, 37 members and visitors.

Additions to membership since last meeting, 11.

The Secretary presented and read a letter from his honor, the Mayor of Philadelphia, transmitting a communication from the London Society for the Encouragement of the Arts, Manufactures and Commerce, offering a prize for a "Dust-Arresting Respirator," and inviting the participation of the members of the Institute in the competition. The prize in question, to be awarded under the terms of the Benjamin Shaw trust, will consist of a gold medal, or £20, "for the best Dust-Arresting Respirator for use in dusty processes and in dangerous trades."

A communication was also read from Dr. A. E. Kennelly, General Secretary of the International Electrical Congress of St. Louis, Mo., 1904, extending an invitation to the members of the Franklin Institute to co-operate in the work of the Congress.

The Secretary was directed to make suitable acknowledgment of these courtesies.

A special election was held to fill two vacancies in the Board of Managers. Dr. Persifor Frazer was elected to fill the place made vacant by the resignation of Mr. F. L. Garrison, and Mr. Chas. H. Howson was chosen to fill the vacancy caused by the elevation of Mr. James M. Dodge to the office of Vice-President.

Col. W. F. Morse, of New York, presented a paper on "The Utilization and Disposal of Municipal Waste," which was illustrated with the aid of numerous lantern photographs. The speaker described the various methods and apparatus employed, and gave some account of the results attained and of the situation of the work in the United States.

Dr. Charles F. Himes, of Carlisle, Pa., followed with an illustrated description of an interesting Decorated Stove-plate Casting, which is no doubt a relic of the earliest iron furnace established west of the Susquehanna River. The speaker's remarks embraced some references to the general subject of this interesting pioneer industry.

The chairman expressed the thanks of the meeting to the speakers of the evening, and announced the meeting adjourned.

WM. H. WAHL,
Secretary.

Committee on Science and the Arts.

[*Abstract of proceedings of the stated meeting held Wednesday, Nov. 4, 1903.*]

MR. CHAS. E. RONALDSON in the chair.

The following reports were adopted:

(No. 2300.) *Process for Utilizing Waste Metals.*—G. H. Clamer, Philadelphia.

ABSTRACT.—This process is the subject of U. S. letters-patent, No. 707,551, August 26, 1902, granted to G. H. Clamer. The invention discloses a new method of utilizing brass-scrap and other waste materials carrying copper, tin and lead, and producing therefrom a merchantable bronze. The report is reserved for publication in full. The Elliott-Cresson Medal is granted to the inventor. [*Sub-Committee.*—Joseph W. Richards, Chairman; A. E. Outerbridge, Jr., Samuel P. Sadtler.]

(No. 2303.) *Measuring Device.*—Edgar Hill, Philadelphia.

ABSTRACT.—This is a patented device (U. S. patents No. 686,455, November 12, 1901, and No. 709,600, September 23, 1902) and is intended for measuring by means of two arms or caliper legs, the distance between the points of these being indicated upon a dial by means of a hand, the motion being so greatly multiplied that the hand upon the dial will clearly indicate very small distances between the points.

One leg of the device is attached to the casing which carries the bearings for the spindles of the various gears and hands, while the other leg is attached, either permanently or by means of a drag-link, to the first gear wheel. From this gear wheel motion is transmitted through several trains to the last spindle to which is attached the rapid-movement hand; while the slow-movement hand is attached to one of the other spindles having any desired ratio of speed.

The drag-link connection between the movable arm and the first gear wheel is for the purpose of transferring automatically the circular movement of the point of the arm into a straight line measurement.

The report recognizes the utility of the device for special purposes, such as measuring a thickness beyond an obstacle, or for finding slight differences in diameter—as where a piece is not round or tapering; also, for the quick measurement of rough iron of miscellaneous sizes. For that and other special uses the device is admitted to be very convenient. A Certificate of Merit is awarded. [*Sub-Committee.*—Wm. H. Thorne, Chairman; Clement Remington, John Rae.]

(No. 2259.) *A Logarithmic Three-Variable Diagram.*—Harrison Everett Ashley, New Bedford, Mass..

(An advisory report.)

(No. 2289.) *Method of Making Sub-Aqueous Foundations.*—H. Becker, Washington, D. C.

(An advisory report.)

The following reports passed first reading:

(No. 2292.) *Double Universal Joint.*—Waterbury Tool Company, Waterbury, Conn.

(No. 2297.) *Lightning Arrester.*—H. M. Shaw, New York.

(No. 2298.) *Rapid Roller-Copier.*—Yawman & Erbe Manufacturing Company, Rochester, N. Y.

(No. 2299.) *Hydro-pneumatic Ash Ejector.*—Horace See, New York.

(No. 2302.) *Concrete Pile.*—Frank Sherman, Philadelphia.

(No. 2164.) *Steam Generator.*—John C. Parker, San Francisco, Cal.

Held over until next meeting. W.

Sections.

[*Abstracts of stated meetings.*]

PHYSICAL SECTION.—*Stated Meeting*, held Thursday evening, October 1, 1903. Prof. Geo. A. Hoadley in the chair.

Dr. Paul R. Heyl, Central High School, Philadelphia, read a paper entitled "A Résumé of our Knowledge of the Physical Properties of Current bearing Matter." (An abstract of this paper has been referred for publication.)

W.

ELECTRICAL SECTION.—*Stated Meeting*, held Thursday evening, October 8, 1903. Mr. Thos. Spencer in the chair. Present, 62 members and visitors.

Mr. W. E. Harrington, General Manager Camden and Suburban Railway, presented a paper on "Rail-Bonds." The communication was an exhaustive historical review of the development of this important element in the operation of the electric railway, and was profusely illustrated by specimens of these devices. The subject was freely discussed. The thanks of the meeting were tendered to the speaker. (The paper will appear in the *Journal.*)

RICHARD L. BINDER,
Secretary.

CHEMICAL SECTION.—*Stated Meeting*, held Thursday evening, October 15, 1903. Dr. Robert H. Bradbury in the chair. Present, 36 members and visitors.

The following communications were presented:

"The Estimation of Commercial Cutch," by Mr. W. E. Ridenour.

"The Determination of Citral in Essential Oils," by Mr. S. S. Sadtler.

Both papers were freely discussed.

Dr. Henry Leffmann made some informal remarks on the subject of preservatives in food products. He called attention to the interesting observation, recently made, that minute quantities of salicylic acid occur naturally in certain fruits, berries and vegetables; and that the finding of traces of this substance in food preparations would, therefore, not necessarily imply that it had been added as a preservative.

Stated Meeting, held Thursday, November 5, 1903. Dr. Harry F. Keller in the chair.

Dr. Robert H. Bradbury read a paper on "Fermentation without Yeast Cells." This was an elaborate historical sketch of the subject of fermentation, describing more especially the recent researches of Dr. Buchner.

The thanks of the meeting were presented to Dr. Bradbury for his admirable résumé of the history of this important theme.

Dr. Wahl gave a brief account of a process for utilizing waste metals, recently devised and put in operation by Mr. G. H. Clamer, a member of the Section, and exhibited a number of specimens to illustrate the application of the process.

W. E. RIDENOUR,
Secretary.

MECHANICAL AND ENGINEERING SECTION.—*Stated Meeting*, held Thursday evening, October 22, 1903. Mr. James Christie in the chair.

The paper of the evening was read by Mr. Luther D. Lovekin, Engineer of the New York Shipbuilding Company, Camden, N. J., describing "A New System of Expanding and Flanging Machinery and Tools."

Mr. Lovekin has devised and perfected a new line of tools and machines for this work, with which he is able to perform all kinds of expanding and flanging for boiler tubes, steam-piping—in short, all classes of iron, steel or copper piping—from the smallest to the largest sizes.

Mr. Lovekin illustrated his paper by showing a full-size machine in operation, by the exhibition of work done, showing the wide scope of the invention, and by a number of lantern slides.

The subject was freely discussed.

The speaker was voted the thanks of the meeting. (The paper will appear in the *Journal.*)

D. EPPELSHEIMER, JR.,
Secretary.

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—*Stated Meeting*, held Thursday evening, October 29, 1903. Dr. Henry Leffmann in the chair. Present, 53 members and visitors.

Mr. John Carbutt, member of the Section, presented a communication on "Improved Methods of Producing Color-Values for Monochrome and Three-Color Printing."

This paper was liberally illustrated by samples of three-color prints and lantern photographs, showing what had been accomplished in the art of making photographic plates color-sensitive.

In the discussion which followed, Mr. L. E. Levy congratulated Mr. Carbutt on the success he had attained in making photographic plates sensitive to red and green.

The second communication of the evening was a paper entitled "Upon Changing Photographic Plates from the Developing to the Fixing Bath without Recourse to the Dark Room," by Mr. Arthur W. McCurdy, of Toronto, Canada. (Read by Mr. U. C. Wanner.)

Mr. Wanner in the discussion of the paper announced that he had experimentally verified the correctness of Mr. McCurdy's statements. He exhibited a number of negatives that had been developed in the dark room and subsequently "fixed" in daylight. One negative, which had been developed in the usual way and had subsequently been exposed to daylight for two days, was "fixed" by Mr. Wanner in the presence of the members.

The subject was further discussed by Messrs. Levy, John Carbutt, Samuel Sartain, Dr. Henry Leffmann, and M. I. Wilbert.

M. I. WILBERT,
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BOARD OF MANAGERS, Second Wednesday of each month, 1.30 P.M.

INSTITUTE, Third Wednesday of each month (except July and August), at 8 P.M.

SECTION MEETINGS, Thursday Evenings of each week, 8 P.M. (except months of July, August and September).

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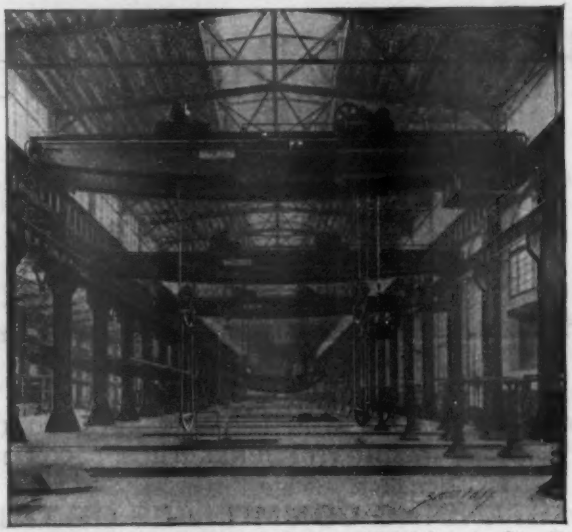

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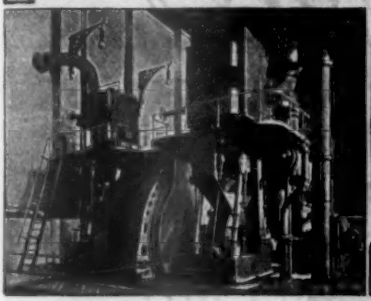

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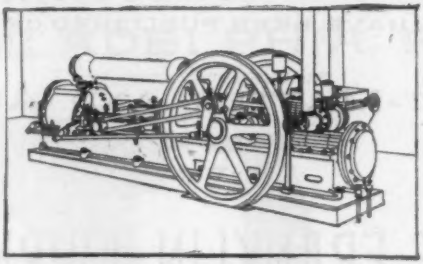

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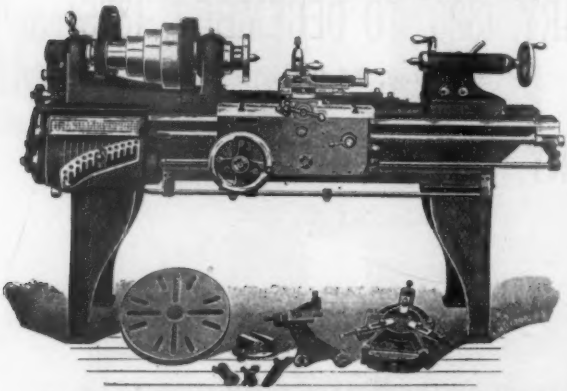

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URIAH A. BOYDEN, ESQ., of Boston, Mass., has deposited with the FRANKLIN INSTITUTE the sum of one thousand dollars, to be awarded as a Premium to

"Any resident of North America who shall determine by experiment whether all rays of light, and other physical rays, are or are not transmitted with the same velocity."*

The following conditions have been established for the award of this Premium:

1. Any resident of North America, or of the West India Islands, may be a competitor for the Premium; the southern boundary of Mexico being considered as the southern limit of North America.

2. Each competitor must transmit to the Secretary of the FRANKLIN INSTITUTE a memoir, describing in detail the apparatus, the mode of experimenting, and the results: and all memoirs received by him before the first day of January, one thousand nine hundred and four will, as soon as possible after this date, be transmitted to the Committee of Judges.

3. The Board of Managers of the FRANKLIN INSTITUTE shall, before the first day of January, one thousand nine hundred and four, select three citizens of the United States of competent scientific ability, to whom the memoir shall be referred; and the said Judges shall examine the memoirs and report to the FRANKLIN INSTITUTE whether, in their opinion any, and, if so, which of the memoirs is worthy of the Premium. And, on their report, the FRANKLIN INSTITUTE shall decide whether the Premium shall be awarded as recommended by the Judges.

4. Every memoir shall be anonymous, but shall contain some motto or sign by which it can be recognized and designated, and shall be accompanied by a sealed envelope, endorsed on the outside with some motto or sign, and containing the name and address of the author of the memoir. It shall be the duty of the Secretary of the FRANKLIN INSTITUTE to keep these envelopes securely and unopened until the Judges shall have finished their examination; when should the Judges be of opinion that any one of the memoirs is worthy of the premium, the corresponding envelope shall be opened, and the name of the author communicated to the INSTITUTE. The sealed envelopes accompanying unsuccessful memoirs, will be destroyed unopened, in the presence of the Board of Managers.

5. Should the Judges think proper, they may require the experiments described in any of the memoirs to be repeated in their presence.

6. The memoirs presented for the Premium shall become the property of the FRANKLIN INSTITUTE, and shall be published as it may direct.

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* The problem has been more specifically defined by the Board of Managers, as follows:—

"Whether or not all rays in the spectrum known at the time the offer was made, namely, March 23, 1859, and comprised between the lowest frequency known thermal rays in the infra-red, and the highest frequency known rays in the ultra-violet, which in the opinion of the Committee lie between the approximate frequencies of 2×10^{14} double vibrations per second in the infra-red, and 8×10^{14} in the ultra-violet, travel through free space with the same velocity."

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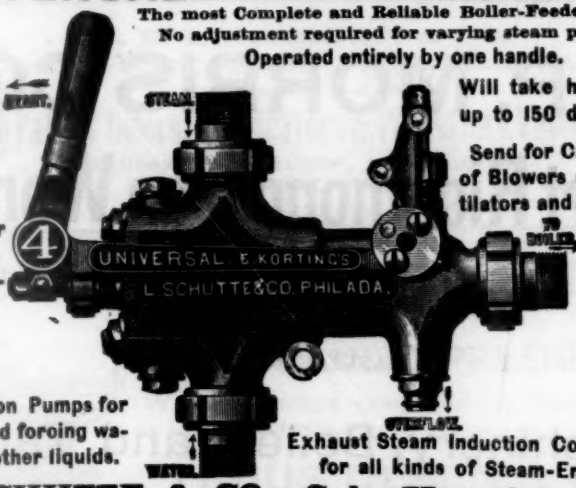

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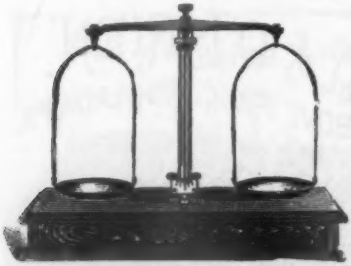

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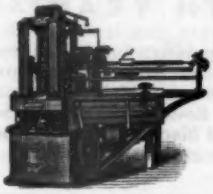

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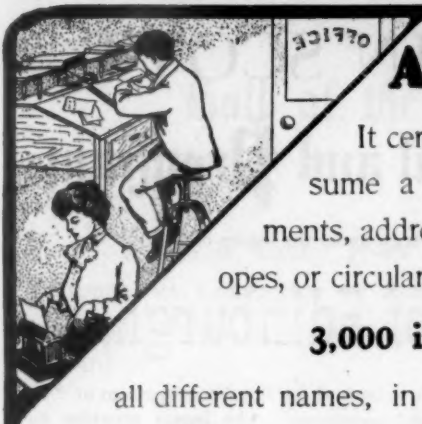

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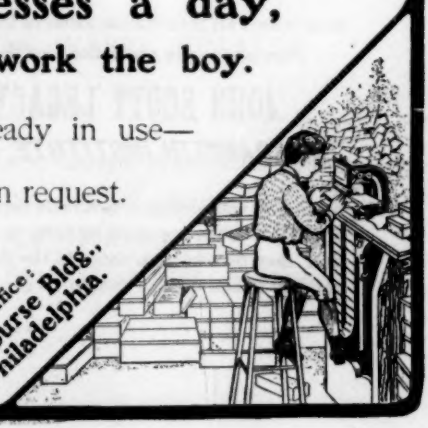

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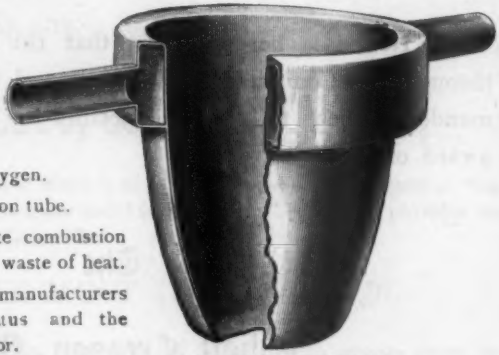

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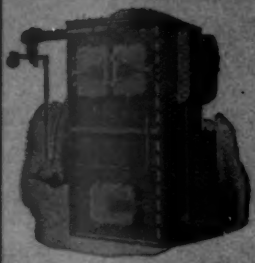

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